Presented by
Dr. Duncan

MANUAL

OF

MILITARY HYGIENE

FOR

THE MILITARY SERVICES OF THE UNITED STATES

BY

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PREFACE

The aim of this Manual is to present in a clear and concise manner the art and science of military hygiene in its latest advances, especially as evolved in this country during the last few years.

While believing that there is a real need for such a book at this time, the writer fully recognizes the great merits of the works on military hygiene already published in this country and which have so much contributed to our progress. To them all, but especially to the classic work of Munson, he acknowledges his great indebtedness.

Within the limited compass of this Manual, it was not deemed desirable to include many subjects more or less connected with hygiene, but pertaining, more particularly, to physiology, chemistry and bacteriology, and fully treated in special text-books.

Although primarily intended for medical officers, the hope is entertained that it will also be found useful and acceptable by all line and staff officers in command of troops, as well as by the student officers of our service schools. To that end, all unnecessary technical expressions have been avoided, but without any sacrifice of scientific accuracy.

In order to elucidate important subjects and render long descriptions needless, as many illustrations as was possible have been used, with the trust that they will greatly add to the practical value of the book.

To Dr. W. M. Gray, of the Army Medical Museum, my acknowledgments are due for the photographic work of the plates and engravings.

VALERY HAVARD.

WASHINGTON, D. C., *February*, 1909.

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ERRATA.

Page 22, 11th line, for "even higher," read *also less.*
Page 51, 9th line, for "no value," read *but little value.*
Page 62, 25th line (title line), for "Scurvey," read *Scurvy.*
Page 154, in caption of cut, for "Fig. 42," read *Fig. 43.*
In same caption, for "Filteration," read *Filtration.*
Page 156, in caption of cut, for "Fig. 45," read *Fig. 46.*
Page 255, in caption of Fig. 94, for "head," read *load.*
Page 378, in caption of Fig. 187, for "1," read *2* before "large Russian hospital tents."

CHAPTER XL.

INTRODUCTION

Hygiene is the science of preserving and promoting health. It seeks out and determines the causes of disease and formulates rules for their prevention and removal. It may then also be defined the science of preventing disease. No science can be more important or beneficial to humanity so long as we consider health the most precious of all our earthly blessings. Prevention is better than cure; therefore, to the world at large, hygiene is of more value than medicine.

But the two sciences are so inextricably blended and mutually bene, ficial that it would be futile to attempt to differentiate them. Hygienists, to be successful, must possess a well-grounded knowledge of medicine-while physicians must avail themselves of the researches and discoveries of hygienists if they wish to do justice to their patients.

Hygiene is usually described as individual and public. Under individual or personal hygiene are grouped the subjects of body cleanliness, diet, exercise and habits, while public hygiene considers all those measures which, under the name of sanitation, are instituted for the welfare of communities, such as water-supply, disinfection, sewerage and disposal of wastes. Sanitation deals with the removal of all conditions favoring the growth and propagation of pathogenic, or disease-bearing, germs; to it may be ascribed the chief share in the beneficent effect of hygiene in saving human lives and extending longevity.

All diseases may be classed under two heads: 1, those arising within the body (autogenetic diseases), due to disturbances of nutrition, assimilation and elimination, the result of a want of harmony between waste and repair, such as rheumatism, gout, diabetes, arterio-sclerosis, tumors, nervous diseases, etc.; 2, those due to causes from without and depending upon the invasion and multiplication of special germs in the body, such as the infectious or zymotic diseases.

Hygiene is concerned in the prevention of both classes. By determining the relations which should exist between diet, work and exercise, it secures a sufficient assimilation of suitable food and a free elimination of wastes, without overstrain of any of the organs; thus are the diseases of the first class guarded against. However, it is especially in preventing those of the second class, among which are the so-called camp diseases, that military hygiene is most efficacious.

For the production of infectious diseases two factors are necessary: the germs must be absorbed in the body by ingestion through the stomach, by inhalation through the lungs, or by inoculation through the skin; and, being absorbed, they must find a suitable soil in which to grow and breed, that is to say, the body must be in a susceptible or receptive state. The hygienist, therefore, should have a sufficient knowledge of bacteriology, but the description and reactions of the pathogenic micro-organisms are of less consequence to him than their mode of transmission and introduction into the human body. Thus we know how yellow fever is conveyed, and this knowledge has enabled us to stamp it out from Cuba and other places, although the causal micro-organism has never been seen. On the other hand, we know the bacillus of leprosy, but on account of our ignorance of the manner in which it effects an entrance into the body, under natural conditions, very little has as yet been accomplished for the prevention of that terrible disease.

As a country develops its material resources under the favorable conditions of peace and acquires wealth, its hygiene, as a rule, progresses correspondingly; the people eat better food, are better clothed and sheltered and make more frequent use of the bath, while the cities and State construct public works of sanitation. The result has been a remarkable fall in the death-rate of all civilized countries during the past quarter of a century, as shown by the following figures from the reports of the Census Office:

In the United Kingdom (England, Scotland and Ireland) the yearly mortality per 1000 inhabitants which was about 22 in 1870, has diminished steadily until the present time, being 18.2 in 1900 and 15.5 in 1905. This means that, since 1870, for each 1000 inhabitants there is a saving of 7.5 lives or, for a population of 40,000,000, of 300,000 lives a year.

In France the mortality fell from 26 in 1820 to 21.5 in 1900 and 19.6 in 1905; in Germany, from 26.8 in 1850 to 22.2 in 1900 and 19.9 in 1905; in Austria, from 32.2 in 1850 to 29.5 in 1890, 26.6 in 1900 and 24.1 in 1905; in Italy, from 27.1 in 1890 to 24.2 in 1900 and 21.8 in 1905; in Spain, from 30 in 1900 to 26.1 in 1905.

In the United States the death-rate for the registration area was 19.6 in 1890, 17.8 in 1900 and 16.2 in 1905. The registration area consists chiefly of cities. The rate, outside this area, namely in rural districts, was only 15.4 in 1900, giving a mean of about 16.3 for the total population. If the same correction be made for 1905, the rate for that year will be reduced to about 15. If, furthermore, we take into account the fact that the colored people, which form such an important

element of our population, have a mortality 60 per cent. greater than that of the whites, it follows that the death-rate of the white population of the United States, considered by itself, must be among the lowest in the world.

The decrease of mortality in some of our principal cities has been as follows:

New York.	25.4 in 1890.	20.4 in 1900.	18.6 in 1906.
Philadelphia	21.3 in 1890.	21.2 in 1900.	19.3 in 1906.
Chicago	19.1 in 1890.	16.2 in 1900.	14.2 in 1906.
Boston	23.4 in 1890.	20.1 in 1900.	18.9 in 1906.
Baltimore	22.9 in 1890.	21. in 1900.	19.4 in 1906.
St. Louis	17.4 in 1890.	17.9 in 1900.	15.6 in 1906.
New Orleans	26.3 in 1890.	22.3 in 1902.	21.7 in 1906.

The progress of military hygiene has fully kept pace with that of general hygiene. The death-rate in our Army was about 15 in 1870, 11 in 1880, and had gradually fallen to 5.11 in 1897, before the Spanish War. As the result of this war, of the subsequent insurrections in the Philippine Islands and of the unusual and arduous conditions of tropical service, the mortality remained for several years above its normal rate, but is again steadily lowering, being 5.63 for the year 1907, in the United States, and 5.81 for the whole Army at home and abroad.

The same improvement is noted in all European armies. Thus in the British Army the death-rate for troops at home was 7.20 for the decade 1875–84 and 4.68 for the decade 1887–96, rising to 5.61 in 1905. In the Prussian Army the rate fell from 4.82 in 1880 to 3.30 in 1890 and 1.89 in 1906; and in the French Army, from about 8 in 1880 to 5.81 in 1890 and 3.14 in 1905.

It is believed that, in the event of war, there will also be a marked decrease from the death-rates for disease which have prevailed in previous wars.

Military hygiene differs from general hygiene only in its application; its laws and principles are necessarily the same. The soldier is subject to the same diseases as the civilian, but in a different degree on account of the special conditions under which he lives. He is to a large extent bereft of his personal freedom; his food and shelter are provided for him, while his work and exercise are strictly regulated. In war time, his food and surroundings are those which military necessity imposes, the

preservation of his health becoming a matter of secondary consideration. The crowding of troops in barracks or camps facilitates the transmission of disease and is an element of danger much more serious than in civil life, but, on the other hand, in a well-governed army the soldier is the object of sanitary measures which, if properly enforced, will, to a large extent, safeguard him against the dissemination of infectious germs.

The vital importance of hygiene, in garrison and the field, has been more fully realized of late years, especially since the Spanish-American War. The investigations carried on during and after this war have shown that the diseases which caused its terrible mortality were mostly preventable, that they resulted from the lack of efficient sanitary measures or their indifferent application. It is the earnest belief of the medical corps that such unnecessary sacrifice of life cannot again occur in our Army, except through unpardonable ignorance or criminal carelessness.

It is now recognized that the sanitary service of an army is not an impedimentum or a necessary evil to be tolerated, but that, on the contrary, it is an essential and integral part of its organization, materially contributing to its fighting efficiency by preventing the depletion from disease of the combatants' ranks, and by such treatment of the sick and wounded as will permit their prompt return to the firing line.

With a fuller appreciation of the importance of hygiene has come, as a natural consequence, a remarkable change in the functions and duties of medical officers. Formerly they were primarily surgeons and so designated in official parlance, but now they are chiefly sanitarians; their principal work is no longer the treatment of the wounded, important as that is, but the prophylaxis of disease. If camp diseases can be controlled and prevented, it is evident that, during a campaign, good sanitation will save more lives than the most perfect surgery; therefore it follows that most medical officers must be good sanitarians at all times, while only comparatively few need be skilled surgeons. The unfitness of the title of "surgeons" applied to them is especially obvious when we reflect that war is an unusual condition, that modern armies live generally in a state of peace, when wounds only result from accident and are comparatively rare, and that the duties of medical officers are chiefly those of physicians and sanitarians.

The wonderfully low ratio of mortality from disease during the Russo-Japanese War had the result of compelling attention to the organization of the medical department of both belligerents; this, although far from perfect, was seen to be much more complete and on a more liberal scale than had ever been the case in any previous war of great magnitude.

The effect, in all civilized countries, was the accentuation of the importance of military hygiene in war and an increased interest in its study and development.

In our service, garrison and camp sanitation is now recognized as specialized knowledge requiring the direction of experts; therefore no part of it is any longer intrusted to non-professional officers, however intelligent and zealous they may be, but only to such medical officers who have acquired this expert knowledge. To them is turned over the entire work of sanitation, initiation and execution. For that purpose, increased authority has been given them and a correspondingly greater responsibility laid upon them. In the performance of their duties as sanitarians, medical officers are now practically untrammelled, the regimental sanitary officer being only responsible to his colonel and to the sanitary inspector, while the latter is only responsible to the commanding general of the division.

The above considerations show the wisdom of Congress in investing medical officers with military rank and military title, so that their authority may be commensurate with their responsibility, for experience has proved that military rank is necessary to confer the power and prestige of authority—and no officer from staff or line, in the field, needs this authority more than the medical officer for the successful handling of the large personnel under his command and the efficient discharge of his duties as sanitarian, physician, surgeon and administrator.

Although it is a well-established policy that all sanitary appliances, such as sterilizers, filters, incinerators, etc., as well as ambulances, must be under the direct control of the Medical Department, when in use, there is still some difference of opinion as to whether this department should not also manufacture and store them in time of peace so that they may always be in readiness on taking the field. But whichever way this is decided, it is certain that the Medical Department will always be more or less dependent upon the Quartermaster's Department for much of its material and hired labor and must therefore receive its thorough co-operation to secure the best results.

In the event of war, the bulk of our armies would necessarily consist of volunteer forces and be under the sanitary care of volunteer medical officers. These officers may be assumed to have all the needful qualifications as physicians and surgeons, but their knowledge of practical field sanitation will always be a variable and uncertain quantity. This is a weak point in our system requiring serious consideration. The remedy, as already successfully applied in several States, consists in

theoretical instruction during the winter months under the supervision of the Surgeon-General of each State and in practical instruction during summer encampments. The sanitary work of the mixed commands of regular and militia troops at our summer camps has been of the highest value as a school of instruction not only to medical officers, but as well to all line officers and enlisted men. The use of sanitary appliances has been clearly exhibited and their beneficial effects upon the health of troops demonstrated in such a manner as to produce a marked impression upon all concerned. It is especially by means of such camps that medical officers will obtain the practical knowledge which they require and that line officers will be made to understand the part which devolves upon them in the work of sanitation.

In the application of the precepts of hygiene, the medical officer, in spite of his best efforts, can accomplish but little if unaided. His labors, to be fruitful, must have the hearty and intelligent cooperation of staff and line. Therefore he must instruct, by word and object-lesson, and carry on a sanitary propaganda which will reach down to every enlisted man. He should particularly endeavor to interest the company officers, for it is through them that the men can be most readily influenced and the enforcement of sanitary measures most easily accomplished. The intelligent soldier, in a disciplined regiment, complies readily with regulations intended for his welfare as soon as he understands their importance to himself and the service.

The War Department has realized the great importance of hygiene in the Army by adding it to the curriculum of the Military Academy and of all our service schools, and it is most gratifying to note how efficiently our young officers, at the very outset of their career, apply the knowledge thus acquired, to the great advantage of the enlisted man.

Military hygiene, to be efficacious and successful, must deal with able-bodied soldiers. The best possible care can never make strong, resistant and useful soldiers of immature, undergrown or otherwise defective youths. In an army composed of men voluntarily enlisted it would seem that only physically perfect individuals should be accepted and enlisted. But this is far from being the fact. It is not always the strong and stout who present themselves to the recruiting officer, nor is it always possible to detect chronic or latent diseases or a predisposition to them, while it also happens that examiners are not as careful or experienced as their duties require. The result is that there is always a certain ratio of sickness due to preexisting conditions—for which the military service is not responsible. Therefore, great care and diligence

are enjoined by the War Department upon all recruiting officers in order to reduce this ratio to a negligible minimum.

Military hygiene is indissolubly bound up with discipline. It is not enough to be familiar with all its precepts, they must be fully and strictly applied, and this cannot be done successfully except through discipline. Laxity of discipline in an army may be the source of many evils, but certainly nothing is more favorable to the dissemination of disease. Assuming that medical officers are equal to their duties, experience shows that the health condition of a command will be directly proportional to its discipline and, therefore, that to preserve the health of troops the action of regimental and company officers is quite as necessary as that of medical officers. This has been exemplified in all modern wars, but especially in the Franco-German and the Russo-Japanese Wars. The difference in the sanitary condition of the French and German Armies in 1870 and 1871 was not less marked than the difference in their fighting efficiency. The Japanese in Manchuria did not discover any new system of sanitation, but they excelled in discipline, prompt obedience to orders and administrative abilities, and this was not the least of the causes which reduced their ratio of sickness to a minimum never before reached by any large army in the field.

The successful application of military hygiene under the best conditions—that is to say, by an efficient medical department to a body of men carefully chosen and under strict discipline—is most strikingly illustrated in the German Army which, since the Franco-Prussian War of 1870, has always had the lowest mortality of any army in the world. The military service being compulsory in Germany and the number of conscripts much larger than the annual contingent required, it is possible to make a careful selection of recruits and reject all the physically imperfect. It is also notorious that stricter discipline prevails in the German Army than in that of any other country. Thus is its wonderfully low death-rate readily and satisfactorily explained.

MILITARY HYGIENE.

CHAPTER I.

MORBIDITY AND MORTALITY IN THE MILITARY SERVICE.

As late as the middle of the 19th Century, the crowding of soldiers in ill-ventilated barracks and the neglect of all hygienic rules resulted in the free dissemination of infectious germs and in enormous rates of disease and death in garrisons, several times higher than in civil life. But since the Crimean War in Europe and the Civil War in America, with the progress of scientific medicine, it has become more and more evident that most of the military morbidity and mortality can be prevented by giving soldiers sufficient air space and the benefit of intelligent sanitary regulations. In time of peace, soldiers are presumed to be comfortably quartered, properly fed and clothed, subject to wise hygienic rules and, to a large extent, guarded from excesses and dangerous exposure by military discipline. They are, besides, chosen men, physically sound when enlisted or mustered in. Under such conditions one would expect them to enjoy at least as good health as males of the same age in civil life. It is true that the danger of conveying disease by contact, direct or indirect, in barracks, even when sufficiently roomy, is ever present and cannot be overlooked. The question is complicated by several interacting factors which add to the difficulty of reaching a clear conclusion.

According to the United States census of 1900, the male population of military age, namely between 20 and 39 years inclusive, was 12,466,309; during the year, this population suffered a mortality of 95,070, or at the rate of 7.62 per thousand. For the period of life from 20 to 29, the rate was 7.11. So far as it is possible to ascertain, England, France and Germany have about the same ratio of civil mortality, being a little less in Germany and a little more in France.

How then does military mortality compare with the above? By consulting the official reports of the last few years, years of peace, the figures appear quite favorable to military life. Thus we find that for

the United States Army (exclusive of colonies) the total mortality (from disease, accident and injury) for 1904, 1905 and 1906 was 6.44, 6.14 and 5.28 respectively, or an average of 5.95. For England, the last available statement (1905) gives 5.61. France reports 3.21 and Prussia 1.86 for the year 1904. These figures show that the rates for the United States Army are higher than those of the leading European countries, but that they are all under those prevailing in civil life. A further study of the subject, however, somewhat modifies this first view. It is found that, in all armies, when soldiers contract incapacitating diseases, not likely to be cured within a short time, they are discharged and returned to civil life, so that their deaths, instead of being charged to army statistics go to increase the civil rates. Thus in 1904, the proportion of discharges per thousand of strength was 48.40 in the French Army, 46.00 in the Prussian Army and 22.90 in the United States Army. In the British Army this proportion was 15.05 for 1905. In the United States Army it increased to 26 for 1906.

The disease which, in the absence of epidemics, makes the greatest number of victims, is tuberculosis. In the French and German Armies most of the discharges are for that disease; as soon as a case of it is clearly diagnosed the patient is invalided and sent home where his death ultimately swells the civil rates. In our service, such a case is sent to the Army sanatorium at Fort Bayard, N. M., where he remains an average period of six months before death or discharge. His death at the sanatorium is charged to the Army rates. The result is that while the tuberculosis rate in the United States Army, for 1906, was 0.78, it was only 0.66 in the French Army (1904), 0.40 in the British Army (1905), 0.20 in the Prussian Army (1904) and 0.28 in the Bavarian Army (1903), the discrepancy being largely due to the process of elimination above referred to.

According to Viry and Marvaud, the ratio of mortality in the French Army should be increased by 4 to give a near estimate of the number of deaths fairly attributable to military life. The same correction should doubtless be made for the German Army. These 4 deaths are to be deducted from the rates of civil life, but owing to the large population of military age in France and, still more so, in Germany, this deduction would only amount to a fraction of one per thousand, a negligible quantity. It is presumed that an increase of 2 would fully correct the rates of the United States Army and the British Army.

In conclusion, it may be said that, in time of peace, the ratio of deaths from all causes, in the armies of the leading nations, does not sensibly

differ from that of the male population of military age, except in the case of the German Army where it is distinctly lower.

However, if, instead of taking the mortality from all causes, we simply compare the rates for disease only, the result is more clearly in favor of military life, for it is a fact that, in the service, in time of peace, more men die of injuries and violent death than in civil life. Thus, in 1900, the proportion of deaths from accidents and injuries, to the total mortality, in the male population of military age in the United States, was only 17 per cent., while in the United States Army (exclusive of colonies) this proportion, for the 3 years 1904–6, is 43 per cent.; the rates of deaths from disease, for those years, being only 3.94, 3.55 and 2.84 per thousand respectively. The number of accidental deaths in European armies is not as high as in our service, but yet decidedly higher than in the civil male population. It is plain, therefore, that we are justified in stating that, in time of peace, modern armies suffer less from disease than the corresponding male civil population, a proof of the efficacy of scientific sanitary measures when enforced by military regulations and discipline.

MILITARY MORBIDITY AND MORTALITY IN TIME OF PEACE.

The diseases of the soldier in time of peace differ from those of war time in their degree of prevalence and rates of mortality. In the United States Army (exclusive of colonies), for the three years 1904–6, the following diseases have been those most prevalent, in the order named:

Venereal diseases, rates of admission,	167.01 per thousand.
Tonsillitis, rates of admission,	66.79 per thousand.
Diarrhea, rates of admission,	64.85 per thousand.
Bronchitis, rates of admission,	55.36 per thousand.
Malaria, rates of admission,	47.31 per thousand.

Influenza.
Alcoholism.
Mumps.
Rheumatism.

In the United States Navy and Marine Corps, for the years 1905 and 1906, the order of prevalence was: venereal diseases, tonsillitis, malaria, bronchial diseases, influenza, rheumatic diseases and diarrheal diseases.

In the British Army, the order of prevalence, for 1905, was: venereal diseases, malaria, bronchitis, influenza and rheumatism.

In the French Army, for 1904: bronchitis, venereal diseases, influenza, rheumatism and mumps.

In the Prussian Army, for 1904: bronchitis, venereal diseases, influenza, rheumatism and pneumonia.

The preeminence of venereal diseases in America and England, as compared with continental European countries, is largely due to the lack of the safeguards used, for instance, in France and Germany where prostitution is subject to police regulations. This matter will be discussed in its proper place.

Tonsillitis, in our Army and Navy, comes second in the order of admissions, while, in all armies, bronchitis is not far below it. This high prevalence of tonsillitis is remarkable, showing the sensitiveness of the tonsils to external influences, as well as some serious defect in the ventilation of our dormitories. The rate begins to rise as soon as winter sets in; then the barracks, often crowded, are tightly shut and the air becomes overheated, close, ill-smelling; conditions most favorable to the spread of tonsillitis by air infection, and favorable also to the incidence of nasal, pharyngeal and bronchial affections mostly included under the general heading of bronchitis. The remedy is more air space and better ventilation.

Deaths result chiefly from the following diseases, in the order named:

In the United States Army, for the years 1904–6: tuberculosis, pneumonia, typhoid fever, appendicitis, measles, alcoholism, organic diseases of the heart.

In the United States Navy and Marine Corps, for the years 1905 and 1906: tuberculosis, pneumonia, typhoid fever, meningitis, nephritis, heart diseases, alcoholism and appendicitis.

In the British Army, for 1905: typhoid fever, tuberculosis, pneumonia, sunstroke, dysentery and alcoholism

In the French Army, for 1904: typhoid fever, tuberculosis, influenza, pneumonia, dysentery.

In the Prussian Army, for 1904: pneumonia, tuberculosis, typhoid fever, pleurisy.

MIILITARY MORBIDITY AND MORTALITY IN WAR.

In time of war, sanitary conditions are necessarily very different from those which should prevail in time of peace. Then everything is ruthlessly sacrificed to strategic exigencies, that is to say, the necessity of confronting the enemy as quickly as possible, in the best position and with the greatest number of men. But, even then, on the march or the

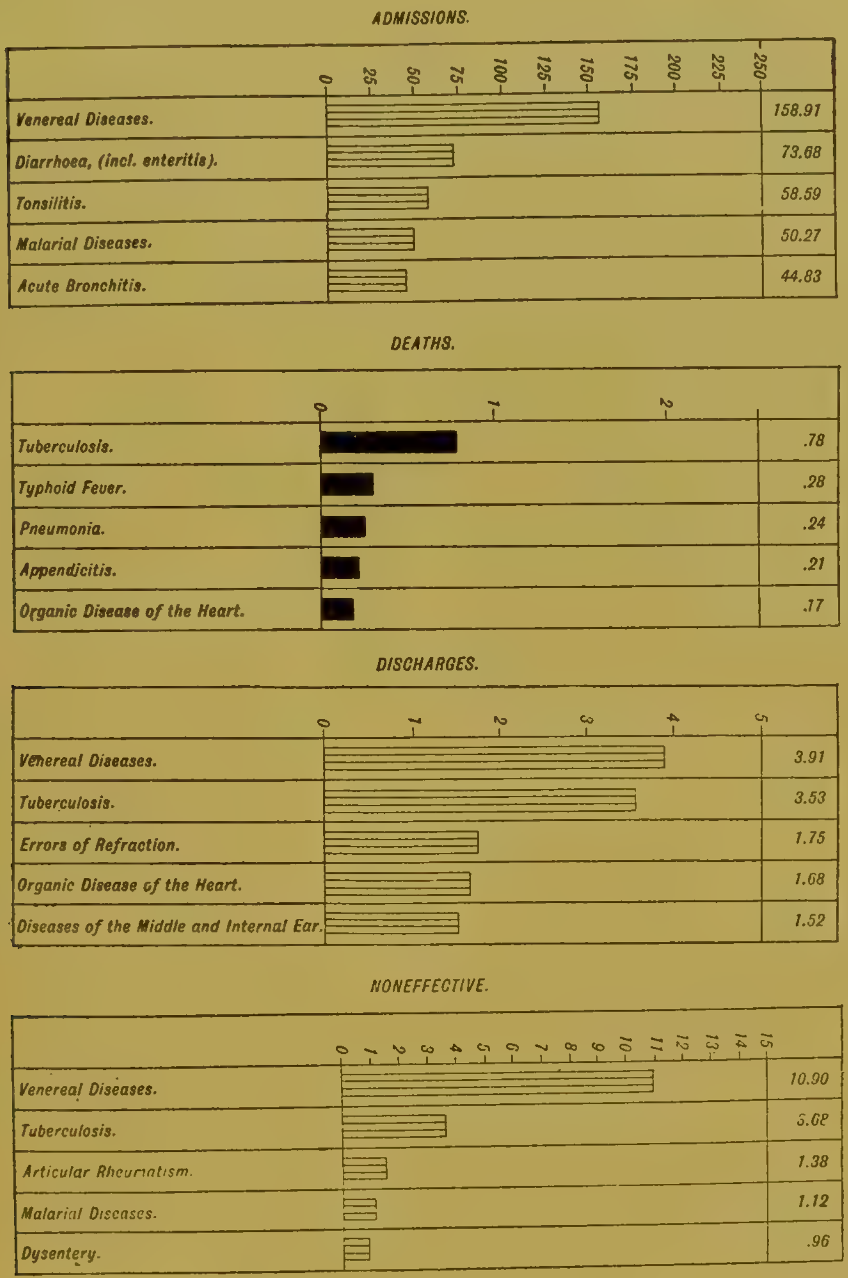


FIG. 1.—Chart showing the relative admission, death, discharge, and noneffective ratios per thousand of mean strength for the five diseases causing the highest rates in the United States proper, for the year 1906.

battlefield, sanitary considerations should never be overlooked or neglected, for hygiene is a source of strength to an army at all times. During a campaign, soldiers are likely to suffer bodily from inclement weather, heat, cold and rain, lack of shelter, improper or badly cooked food, overstrain and, mentally, from excitement and anxiety. Hence,

digestive and intestinal disorders, rheumatic, respiratory, cardiac and nervous affections. Furthermore, the soldier is greatly exposed to infectious diseases and, until hardened by rough service, more susceptible to them. The concentration of regiments in one camp or position cannot always be avoided, while sanitary measures can only be imperfectly applied. The result has been, almost invariably, that, in war, the morbidity and mortality from disease rapidly increase and soon far exceed the rates of the wounded and killed in battle. A few modern historical instances will impress this melancholy fact upon the mind.

During the Mexican War of 1846–47, 22 per cent. of the American regulars died and 14 per cent. were invalided from disease, while only 5 per cent. were killed in battle or died from wounds.

During the Crimean War of 1854–56, the French lost from disease, in round numbers, 70,000 out of 310,000 men, or nearly 23 per cent., while 65,000 were invalided home. Only 7,500 fell in battle. In the same war the British lost 21,000 men from disease out of 111,000.

For the Civil War, 1861–65, the record is as follows:

Killed in battle,	44, 238
Died of wounds,	49, 731
Died of disease,	186, 216
Died, cause unknown,	24, 184

Leaving out of reckoning those who died from unknown cause, it is seen that for each man killed or dead from wounds, two died from disease.

In the Franco-Prussian War, 1870–71, the French mortality from disease vastly exceeded that from battle, but reliable statistics are not available. The Germans lost 17,255 in killed and 14,904 from disease, the first conspicuous exception to the rule that, in war, more men die from disease than from gunshot.

For the Spanish-American War, during the year 1898, the record is as follows:

	From battle.	From disease.
Cuba,	273 deaths.	567 deaths.
Camps in United States,	....deaths.	2,649 deaths.
Philippine Islands,	17 deaths.	203 deaths.
Porto Rico,	3 deaths.	262 deaths.
Total	293 deaths.	3,681 deaths.

or 1 death from battle to 12.5 deaths from disease.

In the war between China and Japan, 1894–95, out of 227,600 Jap-

anese brought into the field, 15,850 died of disease and 1,311 from wounds, a proportion of 12 to 1.

In the Boer War, 1899–1901, out of a total British force of 448,000 men, 7,534 died from wounds and 14,382 from disease (Report of Insurance Actuaries); in addition, 63,644 sick and 8,221 wounded were invalided home.

The Russo-Japanese War, 1904–5, marks a new epoch in military hygiene by demonstrating the possibility, even in a war of great magnitude, to keep the rates of disease much below what had always been considered as the irreductible minimum. During a war of nearly two years duration, the dead from disease were only about one-half the number of killed; often the percentage of sickness among both belligerents was lower than that of garrisons at home. Although the usual diseases were present, none prevailed in an epidemic form, except beri-beri which appears to have been nearly as widespread among the Japanese as during their previous wars, in spite of persistent efforts to eradicate it.

The following is the official Japanese statement for the entire war (including Port Arthur):

Total killed and wounded,	220,812
Total sick,	236,223
Killed in battle and died of wounds	58,887
Died of sickness,	27,158

If we estimate the total strength of the Japanese in the zone of operations at 700,000, we obtain a percentage of 8.41 for the killed and of 3.88 for the dead from sickness.

The official statistics of the Russian Army (exclusive of Port Arthur) are as follows:

Total killed and wounded,	140,953
Total sick,	237,472
Killed in battle or died from wounds,	23,008
Died of disease,	18,830
Missing,	39,729

No satisfactory official explanation has been offered to account for this exceedingly large number of missing. The number of deserters to the hostile Chinese cannot have been very great. It seems more probable that a large proportion of them, perhaps a majority, should be counted as among the killed. Both Col. Hoff and Dr. Follenfant, medical attachés with the Russian Army, estimate at about 14,600 the missing

which should be added to the number of killed, thus increasing the latter to 37,608. But it seems logical that, of the remaining missing, should be also deducted a certain proportion of men taken sick along the extended lines of positions and left to die in Chinese villages unaccounted for. It is believed that 3,000 or 4,000 might thus be properly added to the dead from disease.

Regarding Port Arthur, it is known that the Russian garrison did not exceed 55,000, and that the number surrendered was 41,000, of whom 800 subsequently died (Seaman). It is estimated by Kuhn that at least 10,000 were killed, so that less than 5,000 must have died of disease.

In thus endeavoring to account for a certain proportion of the missing, and by the inclusion of the Port Arthur statistics, the following corrected estimates are obtained:

Killed in battle, as officially reported,	23,008
Added from the missing,	14,600
Killed at Port Arthur,	10,000
Total killed,	47,608
Died of disease, as officially reported,	18,830
Added from the missing,	4,000
Died of disease at Port Arthur,	5,000
Total dead from disease,	27,830

Although the Russians brought over a million men into Manchuria, it may safely be estimated that the number present in the zone of active operations did not exceed 650,000; on such basis we obtain a percentage of 7.32 for the killed and 4.28 for the dead from disease.

Were we to take into consideration the fact that the large contingents of Japanese and Russians, outside the zone of active operations, were also subjected to those field conditions which favor the spread of camp diseases, the rates for disease as above stated could be still further reduced.

The two diseases which formerly caused most of the frightful mortality of military camps were typhus and cholera. Typhus, the *febris bellica* of older writers, was the scourge of armies during the wars of the 18th century and of the Napoleonic era, as late as the Crimean War where it made more victims than all other diseases combined. Under the influence of rational modern hygiene it has disappeared from North America, but sporadic cases are still seen in Europe

and Asia; thus during the Russo-Japanese War it was seldom absent from the Russian base hospitals.

Cholera has not been an important factor in the mortality of late wars, having last prevailed in an epidemic form in the Sino-Japanese War of 1894, but it has so many endemic foci in various parts of Asia that it continues to be a serious menace, especially to our troops serving in the Philippine Islands.

Scurvy, the result of defective alimentation, was also common formerly in armies, especially when besieged and cut off from fresh supplies. Being an easily preventable disease it is now rarely seen.

In the Mexican War, the principal disease is reported to have been diarrhea of an aggravated type; probably this covered many cases of typhoid fever.

In the Crimean War, the most fatal diseases were typhus, cholera and typhoid fever.

In the Civil War, the prevalent diseases, in order of their admissions, were dysentery and diarrhea, malaria, respiratory diseases, rheumatism, venereal diseases and typhoid fever. The most fatal were typhoid fever, dysentery and diarrhea, which have continued to be the chief causes of death in military camps ever since.

During the year of the Franco-Prussian War, the German Army had over 73,000 cases of typhoid fever, equivalent to a rate of admission of 9.31 per cent.

During the Spanish-American War, the prevalent diseases, in order of their admissions, were malaria, dysentery and diarrhea, typhoid fever, respiratory diseases and venereal diseases. The most fatal were typhoid fever for the volunteer camps in the United States, malaria and dysentery for the Philippine expedition, and malaria and yellow fever for the Santiago expedition.

In the Sino-Japanese War, the mortality resulted chiefly from cholera, dysentery and beri-beri.

In the Boer War, about one-half of the disease mortality was from typhoid fever, while dysentery and diarrhea made the next greatest number of victims.

In the Russo-Japanese War, the Japanese suffered chiefly from beri-beri, or kakki, an infectious disease to which the Nippon race is particularly susceptible, more than one-third of the total sickness being due to it (84,545 cases according to Seaman), with mortality of 5 or 6 per cent. Dysentery and typhoid fever were the only other notable infectious diseases, but the number of cases of either, as officially reported,

never exceeded 1 per cent. of all sickness. The case mortality, however, was very high in both diseases.

In the Russian Army, the infectious diseases which caused most of the mortality were typhoid fever and dysentery; then, as secondary factors may be mentioned, in order of their importance, typhus, variola, relapsing fever and scurvy. From the beginning of the war to July 14, 1905, there were 10,449 cases of typhoid fever with 1,041 deaths; on September 1, the number was reported as 17,033 cases with 2,077 deaths. The number of cases of dysentery was approximately one-half that of typhoid fever, with a mortality of 5 to 6 per cent.

CHAPTER II.

SICKNESS IN TROPICAL COUNTRIES.

INFLUENCE OF RACE, AGE AND LENGTH OF SERVICE.

Mortality has been in the past, and is still now, much higher in tropical than in temperate climates. This is due chiefly to the ignorance of hygienic laws and neglect of public and personal sanitation, whereby favorable conditions are created for the propagation of pathogenic organisms, such as those of malaria, tuberculosis, dysentery, cholera, plague, yellow fever, beri-beri and leprosy. It is very doubtful whether a difference in climatic conditions alone has any appreciable effect upon their rate of growth or virulence.

The diseases above named, and others from which the natives of hot countries suffer, are all preventable, in the usual sense of the word, by the application of well-known sanitary measures. On the other hand, the several acute diseases which, in temperate and cold countries, produce a large proportion of the mortality, such as pneumonia, acute and chronic nephritis, cancer, bronchitis, diphtheria, etc., are comparatively rare in the tropics, where, furthermore, all the specific exanthemata (small-pox, measles, scarlet fever, etc.) are very mild. It follows, therefore, that the mortality of tropical lands need not be necessarily higher than in other countries and that, as anywhere else, it is mostly a matter of careful and intelligent hygiene. Thus the rate of deaths in Havana during the decade preceding the Spanish War was 36 per 1,000; under American administration and sanitation this rate fell speedily to 21. During the year 1902, our Army was about equally divided between the United States and the Pacific Islands; while at home the mortality from disease was only 5.66 per 1,000, it was 20.85 in the Islands; but, in 1903, after our medical officers had learned how to contend against the diseases that beset them in their new surroundings, the mortality fell to 11.14 in the Philippines and has continued to decrease. In the same year, the ratio of deaths in Cuba and Porto Rico was only 3.36, notably lower than in the United States.

The mortality of Manila, P. I., is still very high for the natives, among whom sanitary laws are difficult of enforcement, but for the American population it was only 9.05, and for the Spanish population

15.45 per thousand, in 1904, a rate considerably below that of New York City.

During the years 1904, '05 and '06, the average rate of deaths for disease was 3.44 among our troops in the United States and 4.08 in the Philippines; not a marked difference. For 1906, the principal causes of

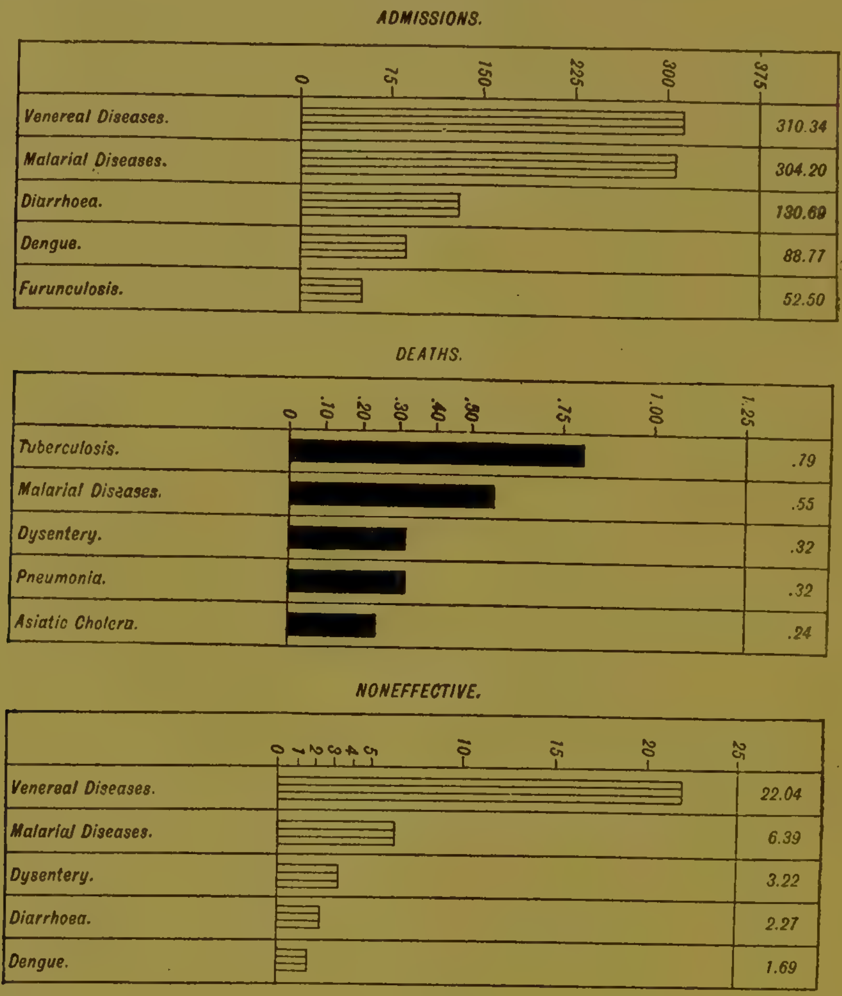


FIG. 2.—Chart showing the relative admission, death, and noneffective rates per thousand of mean strength for certain special diseases in the Philippine Islands (American troops). - (Report of Surgeon General, 1907).

admission, with rates for each, in the Pacific Islands, were: venereal diseases, 310.34; malarial fevers, 304.20; diarrhea, 130.69; dengue, 88.77; dysentery, 43.86. The principal causes of death were: tuberculosis, 0.79; malarial fevers, 0.55; dysentery, 0.32; pneumonia, 0.32; Asiatic cholera, 0.24.

In the Isthmian Canal zone, the total population, including Panama,

Colon and all employes, for the year ending June 30, 1907, was 87,215 with a mortality of 42.08. For the white employes (7,727) the death rate was 15.93, and for negro employes (25,360, mostly from Jamaica and the Barbadoes), 45.34. That the death rate of negroes should be three times that of whites, in a tropical climate, is most remarkable. It would be interesting to know how much of this discrepancy is due to the higher power of adaptation and resistance of the white race; it seems more probable that it should be attributed to the great difficulty of enforcing sanitary regulations among ignorant negroes. Among all the employes, white and black, the most fatal diseases, in the other of their mortality, were: pneumonia (especially among the colored), malarial fever, typhoid fever, tuberculosis, acute and chronic nephritis, dysentery, septicemia, heart disease and meningitis.

Influence of Race.

The statistics of the Surgeon General's Office show that in the United States the rates of admission, discharge for disability and non-effectiveness are lower, but the rate of deaths higher, for colored troops than for white troops. In other words, colored soldiers are less incapacitated for duty on account of sickness than white soldiers, but when attacked by a serious illness are more liable to die. Thus, for 1906, the relative proportion of admissions to the sick report was as 884 to 1,199 in favor of colored troops, while that of deaths was as 4.94 to 10.68 per thousand in favor of white troops. This increased mortality of colored troops is mostly from tuberculosis and pneumonia.

For the Philippine Islands the record is different. There, not only the rates of discharge and non-effectiveness but also the rate of deaths are better for colored than for white troops; thus for 1906, the relative proportion of deaths was 4.07 to 9.42 per thousand in favor of the former. These figures sustain the view that colored troops are more resistant than white soldiers to the injurious effects of tropical service.

Influence of Age and Length of Service.

The experience of the United States Army and of all other armies is that the admission rate to sick report is highest for young soldiers under 20 years of age. This is especially true of typhoid fever. Then the admission rate, as well as the discharge and non-effective rates, fall rapidly up to the age of about 45. The death-rate is high in young soldiers but declines after 20 and reaches its minimum between 25 and 30 years, rising again slowly up to 40 years and rapidly thereafter.

From the point of view of length of service all the rates are highest in the first year, and gradually diminish thereafter, except the death-rate which is lowest in the third or fourth year.

The influence of age is about the same in the tropics as in the United States, except that young soldiers are still more liable to swell the admission rates. The lowest rates of admission, discharge and non-effectiveness are among soldiers past 40 although it is this class which furnishes the highest death-rate.

CHAPTER III.

DISEASES OF THE SOLDIER.

Soldiers may have any of the diseases that male civilians of the same age suffer from; they possess no special susceptibility to, nor immunity against them, but the conditions in which they are placed often favor the occurrence and rapid spread of certain classes of affections.

The diseases which mostly impair the efficiency of the soldier are chiefly the large and all-important group of infectious diseases; then, secondarily, those caused by parasites, exposure to inclement weather and extremes of temperature, immoral or intemperate habits, and improper diet.

Infectious Diseases.

Among these are the most common and dreaded disorders from which troops suffer in active field service and nearly all the mortality results. An infectious disease is one caused by living micro-organisms which, in some way, have been introduced into the tissues of the body. When such a disease can be transmitted from one individual to another, by direct or indirect contact, it is also said to be contagious. Thus small-pox, scarlet fever and measles are very contagious; typhoid fever and dysentery are only contagious through the excreta of patients. On the other hand, malaria, yellow fever and tetanus are infectious but in no way contagious. Therefore it follows that although all contagious diseases are infectious, quite a number of infectious diseases are not contagious.

Disease-producing micro-organisms may belong to the lowest forms of vegetable life, the so-called fission fungi, like the microbes or bacteria of typhoid fever, cholera, etc., or to the lowest unicellular forms of animal life, like the protozoa of malaria, dysentery, etc. Most of them are visible under the microscope; others are ultramicroscopic and invisible, their existence, as in yellow fever, small-pox, etc., being postulated from analogy.

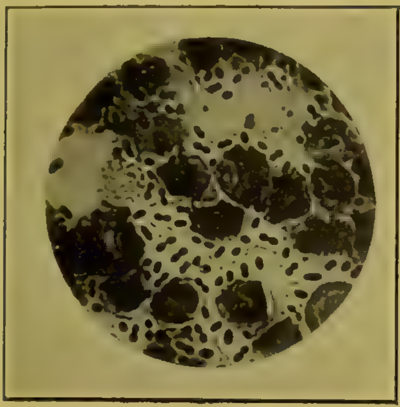
Bacteria abound everywhere, in the soil, in the food we eat and in the air we breathe. Most of them are saprophytes, that is to say, live on dead organic matter and are harmless, when not beneficial, to man. Some others are parasites on living animals, and it is among these that are found the relatively few pathogenic ones, namely the germs and causes of

infectious diseases. These pathogenic germs must be absorbed into the circulation, in sufficient number, to produce disease. They may lie on the skin, or on the mucous membrane of the mouth or throat, or even in the intestinal canal without doing any harm. It is doubtful whether, under natural conditions, they are ever able to penetrate the sound skin, but some pass readily into the system (as in plague, tetanus, etc.) through any cut, break or ulceration of the cuticle, while others are directly injected by stinging insects (as in yellow fever, malaria, etc.). Many are absorded through the respiratory tract (influenza, diphtheria, tuberculosis, pneumonia, etc.) and the alimentary canal (typhoid fever, cholera, dysentery).

Bacteria may do some harm to the tissues through mechanical interference, but their chief noxious action is through the poisonous products, or toxins, which they secrete. These toxins may be soluble and readily diffused in the blood (as in diphtheria and tetanus) or insoluble inside the bacteria cells (as in typhoid fever, cholera, plague). After they reach the blood, the pathogenic bacteria are at once attacked by the natural protective agents of the system, those which make up its defensive or resistance power. The plasma of the blood and serums of the body have bactericidal and antitoxic properties varying in individuals. A certain class of white cells (polymorphonuclear leucocytes) make constant war on invading bacteria, destroying them and their toxins by ingestion, hence their name of phagocytes. Through the action of these natural agents, always active in healthy persons, disease is often averted. They are quite equal to the task of guarding the body against its microscopic enemies under ordinary circumstances; but, should the nervous energy be weakened by some depressing influence, they may be overcome and disease breakout; this explains the paroxysm of intermittent fever which follows a cold bath, or the attack of dysentery which results from exposure to wet and cold. They are also often overcome by overwhelming numbers.

The system in combating the invading germs of many infections develops new antidotes from its own resources, called antibodies (antitoxins, agglutinins, opsonins, etc.) which, in any of these infections, not only neutralize the toxins but bring about changes in the patient's tissues whereby his power of resistance to it is increased and immunity against another attack of it often secured; thus a second attack of typhoid fever, yellow fever, small-pox, etc., is quite rare.

Immunity against certain infectious diseases can also be acquired artificially by vaccination, that is to say, the injection into the skin of a culture of the pathogenic organism after it has been subjected to a temperature just high enough to kill the bacteria. This prophylactic vacci-



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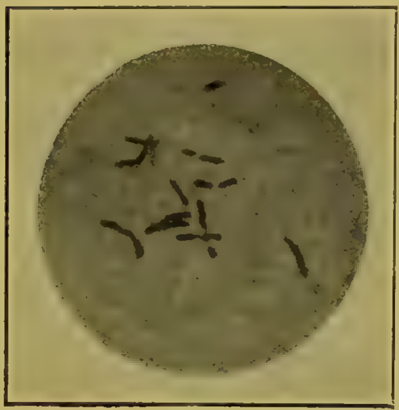

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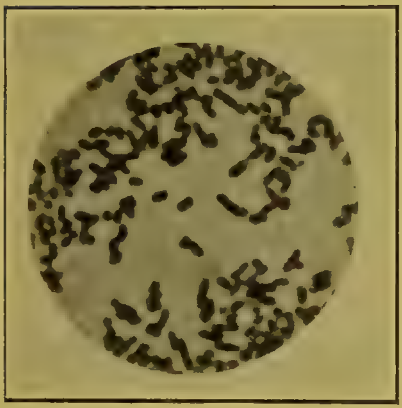

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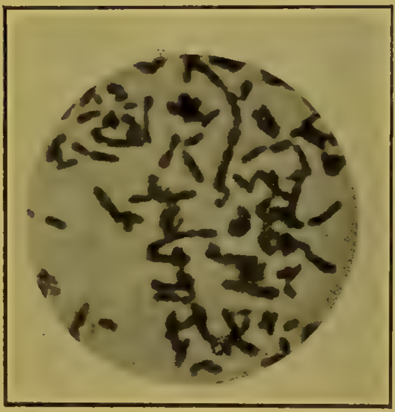

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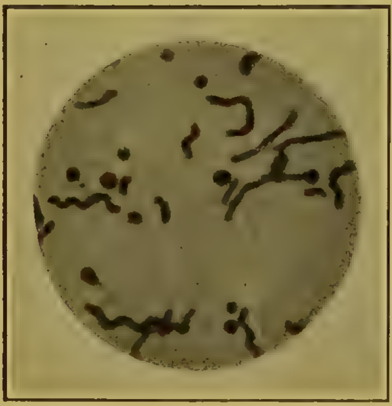

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1. *Diplococcus lanceolatus* (pneumonia) in blood of rabbit (× 1000).
2. Bacillus of tuberculosis in sputum (× 1500).
3. Bacillus of influenza in pure culture (× 1500).
4. Bacillus of diphtheria in pure culture (× 1500).
5. Bacillus of typhoid fever in pure culture (× 1500).
6. Bacillus of Asiatic cholera in pure culture (× 1500).

nation bids fair to give excellent results in typhoid fever, cholera and plague. Antitoxins, readily obtained by the injection of toxins into the horse, are commonly used in the treatment of diphtheria and tetanus.

TYPHOID FEVER.

"Typhoid fever is today, on account of its wide dissemination, the persistent vitality of the infecting organism, the duration and severity of its attack and its large death-rate the most formidable infectious disease with which we have to contend in military life" (Kean).

In garrisons, typhoid fever is easily controlled. Thus during the years 1904–6, the average rate of admissions in the United States Army was only 4.95 per thousand, while the rate of death was 0.28, corresponding to a case mortality of a little over 6 per cent. In the United States Navy and Marine Corps, for the years 1905 and 1906, the rates were almost identical, namely, 4.79 for admissions and 0.29 for deaths. These rates, when compared with those of European armies, are much below those of France and Russia, but higher than those of Austro-Hungary, Germany and the United Kingdom.

But in large camps, where troops assemble for instruction or mobilization, or in the field during active service, it is a very different matter because of the difficulty of disposing of the excretions from the human body. During the Civil War the rate of admissions was 62 per 1,000 of strength, a rate which has since been exceeded in several wars. Typhoid fever being endemic throughout the United States, it is hardly possible for any volunteer regiment, often made up of units from different localities, to come to such a camp without bringing one or more cases in the period of incubation, or already developed. Such primary cases are inevitable; every new batch of recruits may contain some; they should be expected and watched for. But secondary cases, that is, cases infected by the primary ones, are preventable and their occurrence will justify the assumption of imperfect or careless prophylaxis.

Typhoid fever, as seen in camps, assumes many types, some of which vary widely from the classic form and have only been identified by the improved diagnostic methods of recent years. The elaborate report of the Board appointed to investigate the typhoid fever epidemic of the military camps in the United States, in 1898, threw much instructive light upon the subject. The members (Reed, Vaughan and Shakespeare) by studying the medical histories, company by company, in 106 regiments, found that, besides the cases clearly typhoid, there were many others of a few days duration only, diagnosed malarial, which were no longer sus-

ceptible to the infection of typhoid. They also found that previous attacks of diarrhea and gastro-enteritis were likewise in a large measure protective. Hence their conclusion that, during the prevalence of an epidemic of typhoid fever, many of the cases heretofore diagnosed malarial fever or diarrhea are really mild and atypical forms of typhoid, insuring protection against that disease and quite as capable of conveying its infection as the gravest forms. According to this expert Board, hardly one-half of the cases of typhoid were diagnosed as such, and the rate of admissions which was reported as 88.55 per thousand strength should have been 192.65. Long before this, it had been known that the so-called typho-malarial fever of the Civil War was simply typhoid with or without malarial complication.

Typhoid Bacillus.—The specific organism, cause of typhoid fever, is the *bacillus typhosus*, a short, flagellated, sporeless bacterium closely resembling the widespread *bacillus coli communis* and often hard to distinguish from it. It flourishes best at the temperature of the body and ceases to grow below 48° or above 108° F. It is quickly killed in boiling water, or when exposed for 15 minutes to a temperature of 140°. The most intense cold yet produced does not destroy it, and it may remain frozen in ice for months without appreciable loss in virulence. It may retain its vitality for a while in very dry material but complete desiccation soon kills it. It may live and breed for a long time in earth contaminated with organic matter, but soon dies out in clean soil well exposed to the sun. In distilled water it may live for 2 or 3 months, but in ordinary water its life is generally shortened to 1 or 2 weeks and often to 3 days (E. O. Jordan) by competition with saprophytic bacteria. In sewage, it tends rather to decrease than to multiply. In clothing and tentage, this organism may survive several weeks and be carried long distances, thus producing fresh outbreaks in unexpected places.

The typhoid bacillus is passed in vast numbers with the feces of the patients from the beginning of the disease, sometimes from the stage of incubation, and often continues to be discharged long after convalescence has set in. For this reason it is a wise measure not to detail a man on duty in kitchen or mess-room who has had an attack of typhoid fever within three or four months. The bacillus is also passed in the urine in about one-fourth of all cases, often in enormous numbers, as if in pure culture, so that a drop may contain millions. "Because of the frequency with which it is voided, its comparative inoffensiveness, its easy dissemination and the relatively great number of organisms present, infected urine is the most dangerous excretion of the typhoid patient" (Vaughan).

Every case of typhoid must therefore be regarded as highly contagious and treated accordingly. The prompt removal of the patient from his company and regiment, and the disinfection of his clothing and effects will be the first indication; but before cases are recognized, especially in mild, ambulant forms, the latrines and soil of the camp may have become infected. Furthermore, it has been proved that the typhoid organism may breed in large numbers in the gall-bladder of some immune subjects who, while remaining perfectly healthy, discharge, unawares, highly infective stools. Safety then requires that, in camp, all excreta should be considered infected. The soldier may be readily convinced of the danger of fecal matter but it will require special efforts on the part of his officers to make him realize that urine is equally dangerous and must be disposed of with the same care. The strictest measures therefore must be taken to insure the use of urine tubs at night and prevent the fouling of camp grounds.

Dissemination.—Typhoid fever, as a general rule, is spread only by the introduction of the specific organism into the alimentary canal with food or drink; in other words, by the eating of infected food or the drinking of polluted water. Fecal matter and urine being the infectious media, it is important to know how they are disseminated. Man himself is the most active agent in this dissemination, for he may carry them in his alimentary canal and bladder, on his person or clothing, hundreds and thousands of miles. As stated before, at least one man in every regiment of volunteers can be assumed to be infected before he reaches the camp of mobilization, and, as shown by the investigation Board of 1898, an infected recruit may plant the specific bacillus of typhoid in every latrine in his regiment before he is suspected of having the disease. There is no doubt that dried fecal matter and urine are often carried on the skin and clothing of patients before the latter are detected and isolated, as well as on the hands, clothing and shoes of nurses and other attendants, and that the infection may be thus propagated from man to man by personal contact. It is probably in this way that the disease is spread through a family after its introduction, and it is doubtless one of the chief modes of its propagation in the field. This was well demonstrated in some of our camps, in 1898, where the fever was characterized by a series of company epidemics, with a traceable connection in each company between two-thirds of the cases; thus certain tents were badly infected and the majority of their inmates developed the disease, while adjoining tents wholly escaped. The influence of contact was also clearly shown in a camp of Boer prisoners in the hills of Ceylon, in 1901, where over 5,000 men were collected. The

site was high and the water-supply good. "The camp was free of disease until typhoid fever was introduced by some newly arrived prisoners. Within three months there were over 700 cases among the prisoners. The troops guarding them, who were under practically identical conditions as regards food and water, escaped entirely" (Thomas McCrae). It is very probable that the typhoid fever epidemic among British troops at Bloemfontein (1900), attributed to an infected water-supply, was also mostly due to contact infection.

This dissemination by contact is the more insidious and dangerous that it is connected with personal cleanliness and habits, therefore difficult of detection and control. To combat it, soldiers must be made to realize the importance of personal hygiene, especially of washing their hands and cleaning their finger nails frequently. They must also be required, if not supplied with cots, to improvise bedsteads which will lift their blankets and clothing above the dust of a possibly infected soil.

When a command suffers from an outbreak of typhoid fever, in camp, there is also great danger of the tentage, blankets and clothing becoming soiled with urine or fecal discharges. When packed, they convey the infection wherever the command may go. In this way typhoid fever was carried from Fort Snelling, Minn., to Camp Columbia, Cuba, in 1906, and thence to several posts on the Island. In the same manner a perfectly healthy command may carry it to any part of the world. Therefore it is important that canvas and all other fabrics which have been exposed should be thoroughly fumigated before being packed and shipped away; when unpacked it will be a wise precaution to spread them out in the sun.

In civil life, the great epidemics of typhoid fever are generally caused by the specific contamination of drinking water. In garrison or permanent camp the water-supply is mostly obtained from deep wells, piped from wholesome sources, or else purified so as to be above suspicion. In the military camps of 1898, infected water was not an important factor in the spread of typhoid fever. It is very important that the men should be required to use only water and other beverages from authorized sources; there is real danger, for instance, from the unwholesome preparations of the numerous vendors of soft drinks always found in the vicinity of camps and garrisons.

Flies.—Flies are known to be one of the chief factors in the dissemination of typhoid fever. In several of our encampments, in 1898, they were the most active agents in the spread of this disease. The reasons given by the investigation Board for coming to this conclusion were as follows:

1. The latrines contained infected fecal matter.

2. Flies alternately visited and fed upon this infected fecal matter and the food in the mess-tents.

3. Typhoid fever was much less frequent among members of messes who had their mess-tents screened than among those who took no such precaution.

4. The fever gradually died out, in the fall of 1898, with the disappearance of flies, and this at a time when in civil life it is generally on the increase.

Fecal matter adheres readily to the feet and proboscis of flies and may be carried, not only from latrines but also from soiled clothing, bedding or bed pans, to kitchens and mess-tents where it is deposited on food or in drink; or else it may be carried to the men's tents where it is deposited upon their persons or clothing. There is also good evidence that the excrements of flies that have fed on infected feces contain the typhoid bacillus. If it be borne in mind that the female fly lays about 120 eggs, and that from 12 to 15 generations may be bred in the course of a single summer, the abundance of flies in a camp is readily explained and the resulting danger realized.

Flies breed in decaying organic matter, manure and latrines; therefore the indications, to prevent their propagation, are to strictly police the camp grounds, especially the vicinity of kitchens, mess-tents and lavatories, to cart away and burn all garbage and manure, and to darken and thoroughly disinfect the latrines. The danger from flies is practically eliminated by the use of incinerators, and very much lessened by that of the sanitary trough or latrine box. The open pit, when used, must be located as far as possible from the kitchen as prescribed by the Field Regulations. Kitchens, mess-tents and, if practicable, latrines should be screened. Every typhoid patient must also be protected by screen or mosquito-bar, and his soiled clothing disinfected before flies can light upon it.

The Department of Agriculture recommends that, inasmuch as flies lay their eggs preferably in horse manure, each stable should have a separate compartment (screened if possible) into which the manure is piled and freely sprinkled with chloride of lime, until otherwise disposed of. In camps, manure should be burned if practicable, but if it is necessary to let it accumulate for a few days, chloride of lime or quick lime may be used. It is also claimed that flies do not breed in manure when spread over a field in a thin layer soon dried by the sun.

As already stated, the soil becomes readily infected with the typhoid germ when fouled with feces or urine and may therefore be a means of transmitting the disease. This doubtless takes place when it dries up

and, with the dust, is blown in drinking water, on food, clothing or any object handled by the men. Fortunately, it is likely that the specific organism, when thus mixed with dust, soon becomes desiccated and loses its vitality.

Statistics.—The report of the United States Census Office and that of the Registrar General of England and Wales, for the years 1901–1905, show that the mortality rate of typhoid fever in the United States is far in excess of that of most European countries. Thus while this rate was 32.2 per 100,000 of population in the United States, it was only 11.2 in England and Wales, 7.5 in Germany, 11.4 in Japan and 5.7 in Norway. The rate for France is not available, but may be assumed to be even higher than that of the United States. During about the same period, it was 16.2 in New York, 24.7 in Albany, 27.8 in Boston, 29.8 in Chicago and 44.2 in Washington, but only 3.8 in Berlin, 4.3 in Vienna, 5.6 in Hamburg and 12.3 in London (E. O. Jordan). The rate for our Army has also been higher than for the armies of Germany, Austria and England.

It is difficult to account for this difference. We may assume that Americans are as well fed and lodged as Europeans, that although our towns leave very much to be desired in the way of sanitation, more of them are provided with adequate water-supply and sewerage than in England or Germany. Typhoid fever is not a disease of the poor but rather of the well-to-do, being most prevalent among the well-nourished and robust, and making most victims in early adult life, at the time of greatest vitality. It is not improbable that this higher susceptibility in the United States is due, at least in part, to intemperance in eating, especially the eating of meat in which we surpass every other country. This hypothesis is strengthened by the comparative freedom from typhoid fever of countries (outside of cities) whose people are too poor to indulge, more than very sparingly, in a nitrogenous diet. There is enough evidence on this subject (see under *Food*) to make it seem very unwise to allow such liberal rations as to practically put no limitation to the amount of meat that soldiers and sailors may consume in camp or on board ship, as the tendency has been of late years by those who have not yet learned the modern lessons on the necessity of physiological economy in nutrition.

In view of the great predisposition to typhoid fever of our young soldiers, of the usually lax discipline existing among volunteer troops, and of the lack of practical experience on the part of many of their medical officers in the handling of camp diseases, it is plain to see that the prevention of serious outbreaks, if not epidemics, of typhoid fever may always be a difficult problem in case of mobilization on a large scale.

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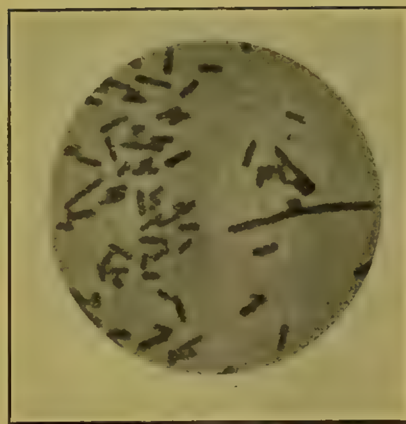

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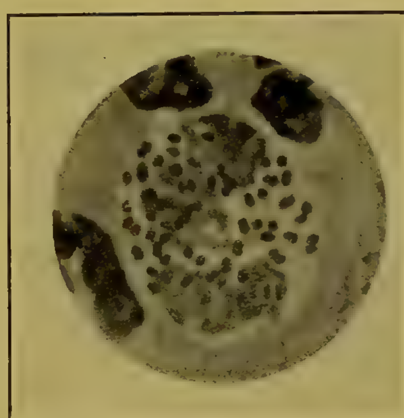

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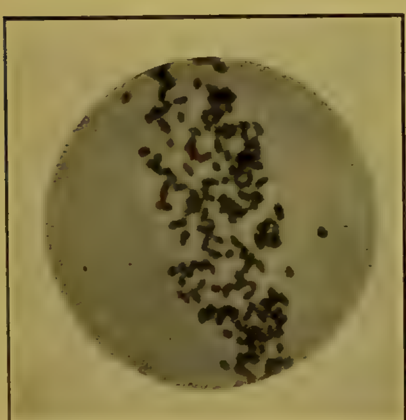

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1. Bacillus of tetanus in pure culture (× 1500).
2. Bacillus of dysentery (Shiga) in pure culture (× 1500).
3. Bacillus of anthrax in pure culture, spores stained (× 1500).
4. Gonococcus in pus cell (× 1500).
5. Micrococcus of Malta fever in pure culture (× 1500).
6. Streptococcus of erysipelas in pure culture (× 1500)

Vaccination.—One prophylactic means, however, has of recent years been developed which seems to be especially adapted to our conditions and more promising than all other preventive measures; this is typhoid vaccination. By the injection of a culture of typhoid bacilli which have been killed at a certain temperature (53° C. maintained for one hour), a considerable amount of protection or immunity is conferred. Anti-typhoid inoculations have been carried on in the British Army since 1897 with very satisfactory results. At seven large Indian stations, in the first six months of 1907, there was an admission rate of 9.80 per thousand and a death rate of 1.36 among 2,207 inoculated, as against an admission rate of 21.32 and a death rate of 5.18 among 8,113 not inoculated. The 17th lancers arrived in India in 1905. On May 1, 1907, out of a total strength of 628 officers and men, 425 had been inoculated. Of the 203 not inoculated, up to that date, 69 had been taken sick and 11 died, while of the 425 inoculated only 2 had been taken sick, without any death. These 2 cases had refused the second inoculation. Of the men who were twice inoculated, none contracted typhoid fever. (Leishman).

The Germans have likewise published excellent results of typhoid vaccination.

Leishman recommends the pectoral region, or the upper arm at insertion of deltoid, as the best site for the inoculation; half to one cubic centimeter of the vaccine contains the required number of germs. The inoculation causes some pain, tenderness and swelling at the point of injection, and usually some constitutional symptoms, such as malaise, headache, nausea and slight fever; these symptoms, however, are not always present and last only 24 to 36 hours. As the inoculations are made twice at intervals of ten days, the total loss of time would probably average 2 to 3 days per soldier.

Measures have already been taken for the preparation of a suitable typhoid vaccine for the United States Army, and it is to be hoped that this radical method of prophylaxis against the soldier's most dangerous enemy will soon be put in operation.

DYSENTERY AND DIARRHEA.

Among troops serving in the United States, diarrheal diseases are quite prevalent, their annual rates of admission for the 3 years 1904–6 being 71.76 per thousand of strength. As a cause of death, however, in time of peace, they are negligible, only 2 men having died of dysentery in 1904 and none since. In the Philippines they are much more serious, having

the highest mortality of any of the diseases on those Islands in 1904 and 1905, and the third highest in 1906.

In war, dysentery and diarrhea assume an importance and produce a mortality which may equal or even exceed that of typhoid fever. In the Medical History of the Rebellion they are thus described:

"These disorders occurred with more frequency and produced more sickness and mortality than any other form of disease. They made their appearance at the very beginning of the war, not infrequently prevailing in new regiments before their organization was complete, and although, as a rule, comparatively mild at first, were not long in acquiring a formidable character. Soon no army could move without leaving behind it a host of the victims. They crowded the ambulance trains, the railroad cars, the steamboats. In the general hospitals they were often more numerous than the sick from all other diseases, and rivalled the wounded in multitude."

They caused 57,265 deaths in the federal armies, corresponding to a yearly mortality of 17 per 1,000, or one death out of every 3.5 deaths from all sickness. The case mortality was 1 death to 395 cases of acute diarrhea, 57 of acute dysentery, 6 of chronic diarrhea and 8 of chronic dysentery. They, besides, caused over 18,000 discharges. It is probable that many deaths from typhoid fever, wrongfully diagnosed dysentery, should be deducted from the above total. Even with this correction the victims from dysentery and diarrhea greatly outnumbered those from typhoid fever. The great predominance of these diseases during the Civil War is surprising and has not been equalled in any other modern war, except perhaps the Sino-Japanese War of 1894–5. During the year of the Spanish-American War, 1898, their death rate was only 2.14. In the Boer War, the relation of the mortality from typhoid fever to that of dysentery was as 6 to 1; in the Franco-German War, this relation was as 4 to 1; in the Spanish-American War as 8 to 1. On the other hand, in the Sino-Japanese War dysentery caused more deaths than all other diseases combined.

Simple diarrhea may result from the ingestion of excessive, indigestible or unwholesome food, or impure water, or from exposure to inclement weather, damp soil or foul air. That it is mostly caused by fermentative or putrefactive organisms is proved by the striking effect of heat upon its rate which, in the United States, is lowest in January and February and highest in August. In camps it is often contagious and may become epidemic, indicating the presence in the stools of pathogenic organisms, perhaps some of the ordinary parasitic and generally harmless bacilli of

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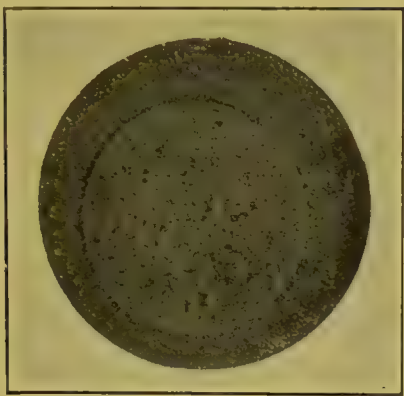
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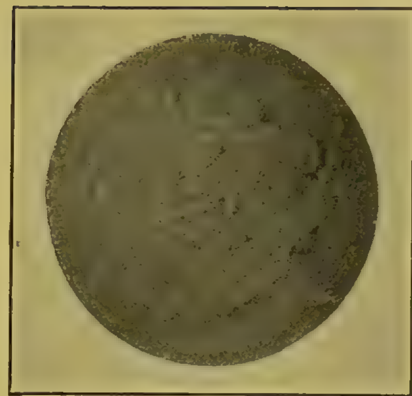
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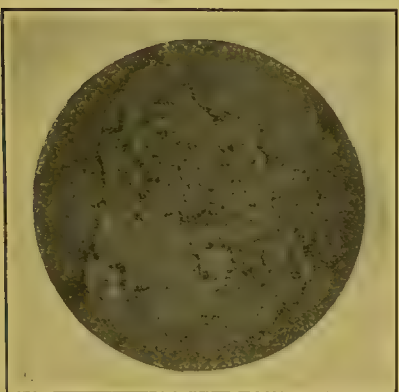
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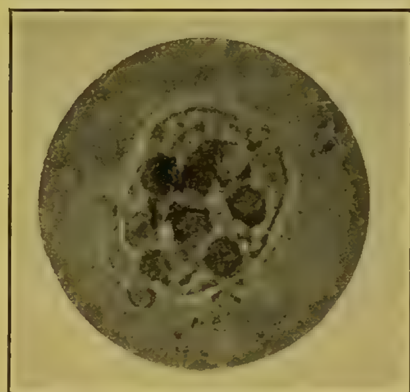
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1, 2, 3. *Entamœba histolytica* in fresh dysenteric stool; the same parasite photographed at 30 second intervals (× 1000).
4. *Entamœba histolytica* in fresh dysenteric stool; parasite filled with blood (× 1500).
5. *Microfilaria bancrofti* in fresh human blood (× 250).

the intestinal canal which assume a certain degree of virulence under special conditions. The younger the soldier the more liable he is to this disease.

The etiology of dysentery has not yet been satisfactorily cleared up; the true causes of its various forms and the symptoms pertaining to each will require much further investigation before we possess a complete knowledge of the subject. Our present information leads us to the conclusion, as stated by Manson, that three factors are concerned in the production of dysentery: (1) weakening or irritating influences such as bad food, purgatives, indigestion, diarrhea, intemperance, etc., which prepare the ground for (2) the specific germs which, subsequently, have their action supplemented by (3) the ordinary bacteria of suppuration. The irritating influences referred to may produce a catarrhal condition which later develops into severe dysenteric symptoms without the operation of any known specific germs; this is the so-called *catarrhal dysentery*.

Two chief types of dysentery are caused by parasites, *bacillary dysentery* and *amebic dysentery*. They are generally distinct, but occasionally one may complicate the other. Bacillary dysentery is characterized by acute onset, often with chill, the presence of the *bacillus dysenteriæ* (Shiga) in the stools, non-liability to liver abscess and no tendency to relapse. This is the epidemic dysentery of armies, especially in temperate climates, and susceptible of becoming highly infectious, although probably never to the same extent as typhoid fever. It is the form that prevailed in the Civil War, in European wars, in the Boer War and in the Russo-Japanese War. The theory advanced by some observers that the bacillus of Shiga is only a pathogenic form of the common and mostly harmless colon bacillus (*b. coli communis*) which, under special influences acquires virulent properties, is not generally accepted. This colon bacillus has been proved to be widespread, probably as ubiquitous as that of typhoid fever, and may become pathogenic, being considered a common cause of severe diarrhea, especially of the very fatal summer diarrhea of children.

Amebic dysentery is characterized by the insidious onset, marked tendency to chronicity and frequent relapses, the presence of amœbæ in the stools and great liability to liver abscess. It is mostly a disease of warm climates and is less contagious than the former, prevailing mostly in a sporadic or endemic form.

Amœbæ are microscopic animalcules in the shape of rounded masses of protoplasm, with nucleus, nucleolus and vacuoles, and often finger-like projections. They are common in all parts of the world and abundant in the tropics. As shown by Musgrave and Clegg they are almost ubiqui-

tous in the Philippine Islands, being found in most surface waters under various forms. According to Schaudinn there are two well-defined species: *Entamœba coli* and *Entamœba histolytica* (*dysenteriæ*), the former smaller and harmless, the latter larger, containing red blood-cells and considered the specific germ of amebic dysentery. Ashburn and Craig corroborate this statement. From extended researches upon this subject Craig concluded that *Entamœba dysenteriæ*, whether fed in milk or injected through the rectum, produces in kittens the typical lesions of amebic dysentery as observed in man, while the *E. coli* when thus used is absolutely harmless (Report Surgeon General, 1905). Musgrave and Clegg, on the contrary, claim that such a distinction between amœbæ is unwarranted, that they all are, or may become, pathogenic. Such view, however, is not supported by the investigations of Ashburn and Craig (Military Surgeon, September, 1907) who found that, of 100 healthy American soldiers examined in Manila, 72 showed the presence of *E. coli* in their stools; that in many of them the organisms disappeared but that, in the larger number of cases, they were still found after the lapse of 9 months, during which the men remained perfectly free from dysentery and diarrhea. Other observers have reached the same conclusion and it may be considered established that a large proportion, sometimes a majority, of healthy people in temperate and tropical countries carry amœbæ in their intestines.

Another form of dysentery, much less common, is that caused by the *balantidium coli*, an infusorial parasite of the intestine, specially studied by Strong and Musgrave. It is chronic in type but its symptoms are not distinguishable from those of other forms of dysentery.

Abscess of the Liver.—One of the most serious sequels, or concurrent diseases, of the amebic dysentery of the tropics is abscess of the liver. There is an intimate relationship between the two diseases, dysentery having been found to be a factor in nearly every case of tropical liver abscess. This disease is rare among the natives, but common among Europeans and Americans, especially the men, its exciting cause being generally intemperate habits and exposure. Women and children seldom suffer from it.

Prophylaxis.—Dysentery, like typhoid fever and cholera, results from the ingestion into the stomach and intestinal canal, with food or drink, of fecal matter containing the infective organism. Like those diseases, it is chiefly water-borne, most of the epidemics of dysentery being fairly attributable to infected water-supply. There is no doubt, however, that, especially in military camps, many cases are also propagated by flies,

dust and personal contact, so that, practically, the same preventive measures are required as in typhoid fever. It is quite probable that so long as the mucous membrane of the intestinal canal is sound and normal, it can protect itself against the pathogenic organisms of dysentery, but any cause which produces an irritation and congestion of the bowels, with consequent diarrhea, such as exposure to cold and wet in combination with unwholesome diet, may break this barrier and bring about an infection of the system. Hence the importance, in the presence of an outbreak of dysentery or of a suspected water-supply, to avoid excesses in eating and drinking, unnecessary exposure to inclement weather and sudden changes of temperature. In the tropics there is usually a great fall of temperature during the night, and persons going to bed without enough covering are liable to wake up chilled. It is to be noted that if the body is uncovered while perspiration is free and evaporation active, the abdomen will be first to be chilled; in this way the incipient diarrhea of dysentery may be started. This sensitiveness of the abdomen is not rare in the tropics and men who suffer from it should wear a flannel abdominal band at night. Such protection, however, is seldom necessary or advisable during the day.

When diarrheal diseases become prevalent in camp, special care must be observed in the use of vegetables and fruits. No uncooked vegetable should be eaten, unless carefully washed with sterilized water or scalded with boiling water. Fruits should be washed in sterilized water and then skinned or peeled, and only the interior pulp consumed.

Any soldier suffering from dysentery or severe diarrhea should be isolated and his feces disinfected.

SPRUE (PSILOSIS).*

A very dangerous form of chronic catarrhal inflammation of the mucous membrane of parts of the alimentary canal, and characterized "by an inflamed, bare and eroded condition of the mucous membrane of the tongue and mouth; by flatulent dyspepsia; by pale, phenomenally copious and generally loose, frothy, fermenting stools; by wasting and anemia; and by a tendency to relapse" (Manson). A tropical disease common in parts of the Philippine Islands, China, India, Africa and the West Indies. Nothing definite is known as to its cause. It may be infectious but it is in no way contagious. Prolonged residence in an endemic area seems necessary to contract it. All depressing influences predispose to it; exhausting diseases, particularly those involving the alimen-

* Not to be confounded with the ordinary thrush or stomatitis of temperate climates, also frequently called sprue.

tary canal, such as dysentery, are apt to terminate in it. Sprue is rare among the natives. To what extent its incidence may be ascribed to any excess in eating or drinking, or unhygienic conditions, has not been determined.

CHOLERA.

Cholera, endemic in India and other parts of Asia, has from time to time spread over Europe and America in an acute epidemic form with case mortality of nearly 50 per cent. Its last visitation to the United States was in 1870–73 when it entered by way of Jamaica and New Orleans. In this country, cholera has ceased to be a serious menace for it is believed that, even should some individual cases elude the quarantine, the infection could soon be controlled and prevented from assuming epidemic proportions. In the tropics, however, cholera still persists in many endemic zones and breaks out now and then, showing the necessity for constant vigilance. In the Philippine Islands, an epidemic began in March, 1902, raged among the natives and was not suppressed until April, 1904. The last case among soldiers during that period was in October, 1903, and no other case occurred until 1905 when there were 9 admissions with 2 deaths; during 1906 there were 7 admissions with 3 deaths.

Cholera is carried by man from country to country, following the routes of commercial intercourse, and is chiefly spread by polluted water-supply. But, like typhoid fever, it is also propagated by flies, infected clothing and utensils, and by personal contact. On being ingested, the germ multiplies in the alimentary canal and abounds in the characteristic rice-water discharges of patients.

The *comma bacillus* is now generally regarded as the cause of cholera, and its detection in the stools as a positive indication. It is short and thick, slightly curved like a comma, sometimes with flagella at the ends. Its growth is arrested below 59° or above 107° F. Freezing does not immediately destroy it, but a temperature of 122° kills it. In the soil, or when dried, it soon dies, but may retain its vitality for a number of days if kept moist, as, for instance, in damp soiled linen (Manson).

Prophylaxis.—Cholera is one of the quarantinable diseases in this country, but its incubative period is so variable, ranging from a few hours to ten days, that efficient quarantine is difficult. The official period of detention is five days.

The quality of the water-supply should first receive attention. No water that is not clearly above suspicion should be used for drinking,

cooking or bathing. A sound mucous membrane is much more likely to resist the invasion of the comma bacillus than if abraded; therefore any cause of digestive disturbance and intestinal catarrh must be carefully avoided. The measures of prevention against flies already mentioned under typhoid fever and dysentery, must be likewise strictly applied. Raw vegetables and fruits, especially from native markets, are dangerous. All patients must be kept in strict isolation, and their bodies, discharges, clothing and bedding thoroughly disinfected.

The following practical rules enforced among American troops in the Philippine Islands during an epidemic of cholera, are well worth remembering:

Do not visit native houses and shops or partake of native food or drink of any description.

Do not drink, or brush teeth with, any other than distilled or sterilized water.

Do not eat cold or uncooked food, except bread and crackers; all food must be freshly cooked and served hot.

Wash all crockery, glass, knives, forks, spoons, etc., immediately after meals with water that has been raised to a boil.

Boil dish cloths frequently.

Protect all food from flies by gauze or wire netting and do not place it upon the table in advance of the meal hour.

Keep the kitchen and mess-room scrupulously clean, carefully removing scraps of food and particles of refuse likely to draw flies.

Wash your hands before entering the mess-room.

Keep all slops and garbage in closed garbage cans.

Take special care of sinks if sewerage or incinerators are not used.

The prophylactic inoculation of a culture of the comma bacillus, or cholera vaccination, first introduced by Haffkine and of late years practised on a large scale in India, has given highly favorable results and will prove an efficient weapon should cholera again be allowed to ravage Europe or America.

TUBERCULOSIS.

Tuberculosis, in time of peace, in armies as in civil life, causes more deaths than any other disease. During the three years 1904–6, its average annual mortality among American troops, in the United States and colonies, was 0.67 per thousand. The number of admissions in the Philippines and other tropical possessions is not any greater than in the United States but the course of the disease is more rapidly fatal. During

the year 1906, the cases contracted in the United States and the Philippine Islands were computed separately; the former giving a mortality of 0.78 and the latter of 0.79 per thousand. In the United States Navy and Marine Corps, for the two years 1905 and 1906, the mortality was 0.58. If we compare the rate for our home troops (0.78) with the rates given in the last available reports of foreign armies, it is found that our mortality from tuberculosis is more than twice that of the British and Austrian Armies, more than four times that of the Prussian Army, and even in excess of that of the French and Russian Armies. But, as already stated, such statistics are misleading and of but little value for purposes of comparison, for the reason that, in our service, incipient cases are sent to Fort Bayard sanatorium and kept there an indefinite time before being discharged, often until death, while they are much more promptly invalided in European armies.

If we compare our census reports with those of the Registrar General of England and Wales for the period 1901–5, it appears that the mortality rate of the United States for tuberculosis averages 70 per 100,000 of population, which is greater than that of England, Scotland, Italy, Spain, Belgium and Japan, but smaller than that of Germany, France and Austria. In this connection, we must also bear in mind the great susceptibility of the colored race to tuberculosis, furnishing a rate three times as high as that of the white, so that, were the white population alone considered, the tuberculosis mortality in the United States would compare very favorably with that of most civilized countries.

Not only is tuberculosis the most deadly disease in the Army, but also that which, for the year 1906, caused the highest rate of discharges, namely, 3.11 per 1,000 of strength; the next highest rate, 3.06, being caused by venereal diseases.

At first thought it would seem that in our Army, where all the men are carefully examined and selected, tuberculous recruits could be entirely excluded. But this has been shown to be impracticable. Men may carry the bacillus in a latent or passive form (in the lymphatic nodes, for instance), only awaiting such determining causes as are encountered in the military service to light up an active process; or else the infection is in such incipient stage as not to be recognized by the ordinary methods of examination. Thus Franz found that 60 per cent. of the young recruits of an Austrian regiment reacted to tuberculin. It is also well known that a majority of cases, in all armies, are first taken sick in the first six months of service, too soon after leaving their homes to ascribe their infection to military conditions. A certain proportion of recruits, therefore, whether

conscripted or voluntarily enlisted, although carrying the fatal germs of tuberculosis, will be accepted. Cornet estimates this unavoidable percentage for the German Army at 0.42 per cent. From the records of the Fort Bayard sanatorium, it seems quite likely that a large proportion of the soldiers who die there of tuberculosis, or are discharged on account of it, had contracted it before enlistment. Thus Bushnell found that, of the 89 patients discharged for pulmonary tuberculosis from January 1 to August 31, 1906, much more than one-half had been examined for enlistment or reenlistment, and passed as sound, only about one year before their admission to the sanatorium, too short a period to dispel a strong presumption that they were already infected at that time.

It is safe to assume, with Bushnell, that there are at all times, in our Army, hundreds of undetected and unsuspected tuberculous soldiers. Even after symptoms have developed and become detectible, soldiers may continue to serve a long time with their companies before presenting themselves for treatment, not realizing the seriousness of their condition. Very often a tuberculous soldier is sent to the hospital only when the attention of his captain has been called to his chronic cough and expectoration, and not till after the patient has had the opportunity to infect his dormitory and endanger the health of his comrades.

The infectious organism, *bacillus tuberculosis*, is a minute, colorless rod, with regular outlines and slightly rounded ends, about five times as long as it is thick. As found in sputum it varies in length from one-fourth to one-half the diameter of a red blood-cell.

It is chiefly excreted in the sputum, or spittle of the patient, so that his expectoration for 24 hours contains billions of it. It sometimes escapes in the urine and feces which, in advanced cases, may thus infect clothing and bedding, as well as the hands of the unclean. Children may also become affected through cow's milk. But, so far as adults are concerned, especially soldiers, the only mode of infection worth considering is by inhalation, the breathing in of the droplets and particles of saliva ejected by patients in speaking, coughing and sneezing, or of the sputum, when, after drying and being ground up, it becomes part of the atmospheric dust. This infective material, inhaled with the air, is absorbed through the mucous membrane of the mouth or of the upper air passages.

The tubercle bacillus is destroyed in water or milk at a temperature of 150° F. maintained for 20 minutes, but, like that of typhoid fever, not by any degree of cold. In dry sputum, exposed in thin layers to the direct sunlight, bacilli lose their vitality in a few hours, and much more quickly if the sputum is in the shape of floating dust, but may resist several days,

even in dust, if only subjected to diffused light. In thick masses of sputum, in which the coagulation of the outer surface forms a protective covering, the bacillus may remain alive several months.

Prophylaxis.—Nothing has been more satisfactorily proved, of late years, than the preventive and curative effect of fresh air in tuberculosis; fresh air has accordingly become the prominent factor in the treatment of this disease. No dormitory should contain more beds than it has room for; this is the first principle in barrack hygiene, but one still insufficiently appreciated and frequently violated by the responsible authorities. Each man is entitled to a minimum of 60 square feet of floor space and 720 cubic feet of air space. To give him less is to greatly increase his chances of contracting infectious diseases, and the disastrous effects of overcrowding are shown in no more striking way than in the rising rates of tuberculosis. But it is not enough to provide sufficient room; it is also necessary to supply adequate ventilation so that each man will get from 2,000 to 3,000 cubic feet of fresh air every hour, without draft. With plenty of air space and free ventilation, the danger of inhaling enough bacteria, of any disease, to become infected is greatly reduced if not entirely eliminated.

We may fairly assume that, in each company and barrack, there are or may be at any time one or more individuals in the infective stage of tuberculosis. The first care of the responsible officers must be to remove all such cases as soon as recognized. To that end the non-commissioned officers should be instructed to regard as suspicious any man, especially a recruit, with an habitual morning cough, and to send him to the surgeon for examination. Under existing regulations, all cases of tuberculosis, as soon as clearly diagnosed and when in condition to travel safely, are sent to the Fort Bayard sanatorium, N. M., where they remain until death, discharge or return to duty. The high altitude of the region, its equable temperature, dry air and abundant sunshine are the qualities of climate which make it most suitable for the cure of that disease. The institution subserves three ends: first, segregation of the tuberculous; second, care of far-advanced cases; third, cure or arrest of the disease in incipient and moderately advanced cases. The majority of the patients whose disease is not so far advanced on admission as to end in death within the year, have their lives prolonged indefinitely. Too often, however, the disease is only discovered during an exacerbation due to the breaking down of the tubercle, and when already too far advanced to expect the best results; but no case is ever refused admission on accout of its severity. The remoteness of this sanatorium from the majority of posts is its main ob-

jection; should a patient be subjected to the necessary journey of 3 or 4 days while in a high febrile condition, he may lose irrecoverable ground; such patients, before undertaking the journey, should be kept in bed until the fever abates. Comparatively few men, when cured, are returned to duty, for the reason that by that time there is such a small fraction of his period of enlistment left that it is deemed better to discharge him than to subject him to the discomfort of being looked upon, in his company, as an object of suspicion.

A similar sanatorium for the Navy and Marine Corps has also been established at Las Animas, Colo.

Since the bacilli are spread through the sputum, strict rules must be enacted and enforced against the habit of promiscuous expectoration, a habit as dangerous as it is loathsome. Spittoons should be provided, partly filled with a disinfectant solution, and anybody found guilty of fouling the floor, walls or furniture of his squad-room or dormitory with his expectoration, mercilessly dealt with. But, as in everything else when dealing with intelligent men, more is accomplished by appealing to the understanding than by threat of punishment. All enlisted men should receive such primary instruction in practical hygiene from their company officers or medical officers, as to know the principal diseases to which they are exposed and the measures to take to avoid them. In this way each man is interested in contributing to the general good health of his company and post. All apartments which have been occupied by cases of tuberculosis must be thoroughly disinfected. Clothing and bedding should be preferably steamed or boiled. In the case of a barrack, after fumigation, all woodwork should be gone over with a solution or spray of formalin, phenol or lysol.

Since it is a fact that there are cases of undetected tuberculosis at most of our military posts, it is not unreasonable to assume that every barrack in the service is more or less infected, or may become so at any time. In view of the serious loss entailed upon the Army by the mortality and discharge rates of this terrible disease, it would not seem too much to require that every dormitory and guard-house, at permanent military posts, should be carefully disinfected once a year.

CHAPTER IV.

MOSQUITOES.

Of all insects, the mosquito is preeminently the worst enemy of man, for not only does it disturb and irritate him with its sting but also infects him with the germs of several diseases. It is known that the mosquito is the chief and probably exclusive factor in the transmission of malaria, yellow fever, dengue and filariasis, and surmised that it may also play a part in the dissemination of other infectious disorders.

A brief study of this insect and of the principal species concerned in the propagation of disease is therefore necessary.

Of mosquitoes there are many genera and numerous species. They belong to the order Diptera or 2-winged insects, with head, thorax and abdomen, and three pairs of articulated legs attached to the thorax. The head consists chiefly of the large compound eyes, the feelers or antennæ, and the mouth parts, namely, the palpi and proboscis. The sexes are readily differentiated by the antennæ which, in the male, bear long, plume-like, silky hairs, and, in the female, short, scant hairs (Fig. 7). The palpi (mouth feelers) vary in length according to sex and species. The proboscis (sting or beak) consists of six distinct piercing elements, or stilets, enclosed and protected in a sheath called labium. This sheath does not penetrate but bends backward while the stabbing elements are thrust into the animal or vegetable from which the mosquito seeks food. These elements form a tiny channel along which the blood or other food is sucked into the mouth cavity.

Mosquitoes feed mostly on vegetable juices, the male exclusively so, but the females of most species, when the opportunity offers, also suck the blood of mammals, birds and other animals. The male mosquito, not being a blood sucker, takes no part in the propagation of disease; the female only bites and infects animals. This infection takes place through the salivary glands in which are found the malarial germs in great numbers. While the female sucks blood, the secretion of these glands is ejected into the tissues of the bitten animal through the salivary duct and down a minute canal which opens at the tip of one of the stabbing elements of the proboscis. This secretion contains also an irritant poison which causes the smart and swelling of the sting. The function of this poison appears

to be to determine a flow of blood to the bitten part and prevent its coagulation.

The female mosquito lays her eggs, so far as known, always on the surface of water, more or less still or stagnant, on which they float. They are glued together in boat-shaped masses of several hundreds, a quarter-inch or less long (Culex), or may lie more or less loosely in groups of a few scores (Anopheles). See Fig. 4. They hatch in a couple of days, giving birth to the larvæ or wigglers which at once exhibit great activity in

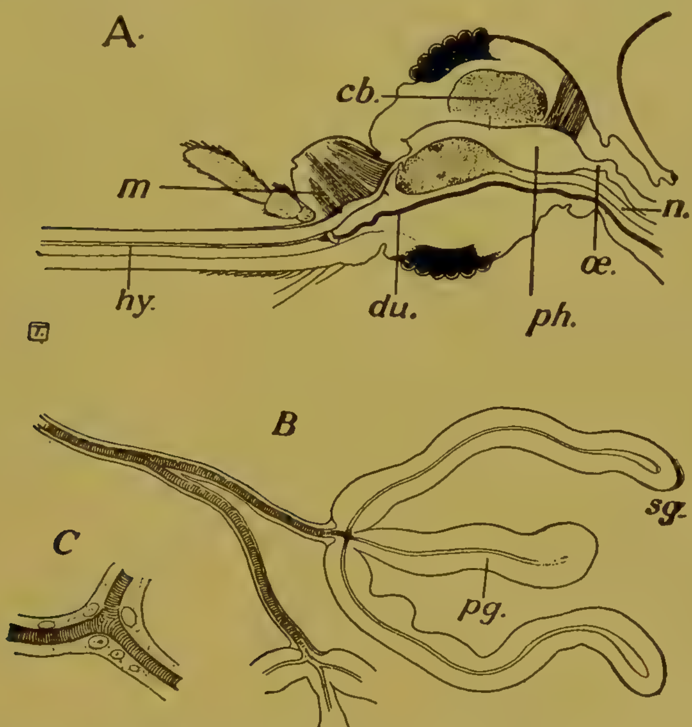


FIG. 3.—Dissection of head of mosquito: A, Median section of head, showing *du*, the veneno-salivary duct, with its insertion in *hy*, the hypopharynx; *cb*, cerebrum; below this are the cerebellum and the pumping enlargement of *œ*, the œsophagus; *m*, muscle; *n*, nerve commissure. The other parts have been removed. B, the veneno-salivary duct, showing its bifurcation and the three glands on one of its branches; *pg*, poison gland; *sg* marks the upper of the two salivary glands. C, the bifurcation of the duct with its nucleated hypodermis. *Manson*

feeding themselves. Being air breathers, much of their time is passed at the surface of the water with the breathing tube (near the tail) protruding into the air (Figs. 5 and 6). After undergoing several moultings, the larva, in eight, ten or more days, becomes transformed into the pupa which, unless disturbed, quietly floats on the surface of the water. In about two days the pupa case bursts and the perfect insect emerges from it. The entire period elapsing from the laying of eggs to the birth of the full-fledged mosquito occupies from 8 or 10 days to 3 or 4 weeks, according to species

and also to climate and temperature, the process being particularly active in hot, damp weather. The same female may lay eggs several times and become the ancestor of many successive generations during the summer. Few males outlive the fall and winter, but impregnated females hibernate in sheltered places, ready to lay eggs as soon as the temperature permits in the spring. Larvæ may also pass the winter in ice without being killed, reviving as the ice melts and then developing into perfect insects. It is likewise probable that eggs laid in the fall may remain frozen through the winter and hatch in the spring. In tropical countries, mosquitoes breed

FIG. 4.—Mosquito eggs. (1), Egg-boat of *Culex* seen from above; (2), the same, side view; (3), separate *Culex* eggs; (4), eggs of *Panoplites;* (5), eggs of *Stegomyia;* (6), the same, more magnified; (7), group of *Anopheles* eggs; (8) and (9), eggs of *Anopheles maculipennis*, showing lateral floats.

throughout the year, except during the dry season when the female remains inactive, waiting for a rainy spell. It has been noted that eggs laid in water which dries up before they hatch, may retain their vitality for a number of days.

Although, when scenting a prey, it is persistent in pursuing it, the mosquito does not usually take long flights, seldom straying far from its breeding place. In a town, each square or street is generally responsible for the mosquitoes that plague it. In the absence of water, mosquitoes will

fly short distances in search of suitable places to lay their eggs; or where they breed in crowding swarms, the instinct of self-preservation leads them to allow themselves to be carried away by the breeze. Governor's Island, in the bay of New York, is periodically infested with swarms of mosquitoes in summer; careful inspection has failed to discover any breeding place on the island, and as they appear with easterly winds the inference

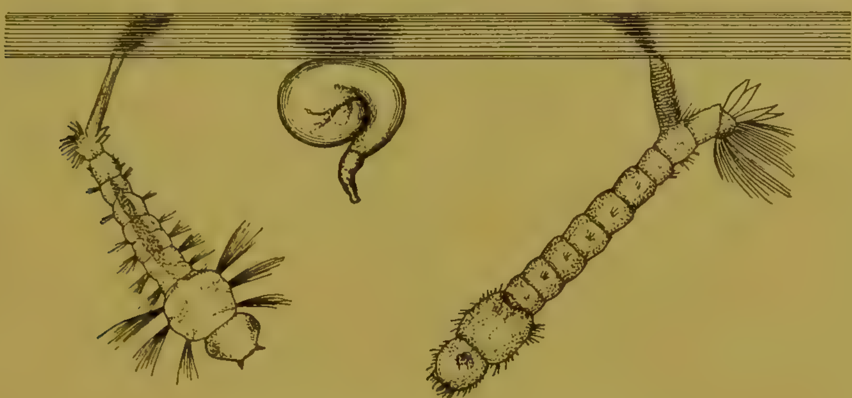


FIG. 5.—Larvæ and pupa of Culex.

is justified that they are blown from Long Island, probably a distance of several miles. As a general rule, however, as soon as the wind begins to blow, mosquitoes seek shelter in the grass and in the lee of shrubs and trees. It must be borne in mind that they are readily transported to distant places by ordinary vehicles of communication, such as ships, trains, carriages, etc., so that they may suddenly appear where they have

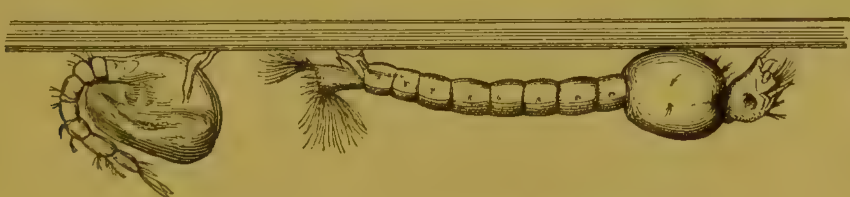


FIG. 6.—Larvæ and pupa of Anopheles.

never been known before, or reappear where they have not been seen for many years.

Isolated mosquitoes may exceptionally appear, one or few, in unexpected places and soon again disappear, but, as a general rule, their presence anywhere indicates that they are bred in some neighboring marsh or pond on a large scale, or else in holes, cisterns, barrels or gutters, covering a large area, for unless they have favorable recruiting grounds they soon become extinct.

CLASSIFICATION AND DESCRIPTION OF DISEASE-BEARING MOSQUITOES.

In the order Diptera, the mosquitoes form a distinct family known as the *Culicidæ*, deriving its name from the typical genus *Culex* which is the most abundant.

Mosquitoes are distinguished from other insects by the whorls of hairs on the antennæ, long and thick in the male, short and sparse in the female; a long beak or proboscis, and fringes of scales on the veins of the wings.

The following subfamilies, genera and species include all mosquitoes known, or reasonably suspected, to transmit disease. Apparent similarity

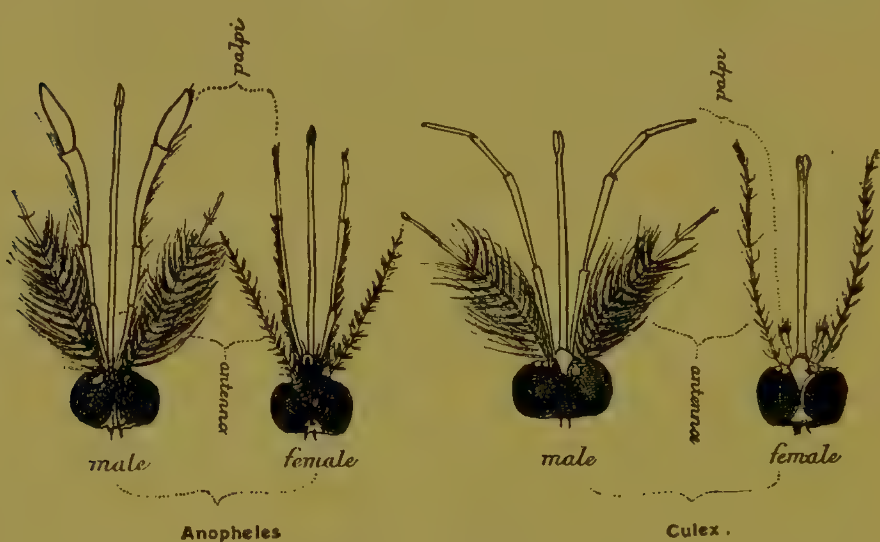


FIG. 7.—Heads of mosquitoes showing the difference between Culex and Anopheles in both sexes (*Giles*).

of structure between allied species may not necessarily imply the same pathogenic capability, but with our still very incomplete knowledge of the subject it seems logical and safer to consider such similarity a reason for suspicion.*

A. Subfamily **Culicinæ**.—Palpi short in the female, long in the male; first submarginal cell as long or longer than the second posterior cell.

1. **Culex**.—"Head ornamented with narrow curved scales over the occiput, and upright forked scales, especially thick on the back of the head; flat scales on the sides." Wings with small median scales, and thin linear lateral ones, to the veins.—Large and unwieldly genus of which *C*.

* For muuh of this information, I am indebted to Dr. Clara S. Ludlow, instructor on mosquitoes in the Army Medical School.

pipiens, the common European mosquito, is the type. It is remarkable that of the numerous species of Culex, only one is positively known to be disease-bearing.

C. fatigans (*C. pungens*).—Thorax clothed with golden scales and three lines of black bristles; abdominal segments nearly black, with straw-colored bands; legs generally dark brown.—Found throughout all the warmer parts of the world, as a purely domestic species, with the same

FIG. 8.—Stegomyia fasciata.

general distribution as *Stegomyia fasciata* but found much further north and all the year round, extending in this country through the northern States to Canada. Its individuals probably outnumber those of all the rest of the family (Giles). This Culex is the intermediary host of *Filaria bancrofti* which it transmits to man. It seems to be also the chief factor in the transmission of dengue.

2. **Stegomyia**.—Head scales all flat and broad. Abdomen completely covered with flat scales. Wings with small scales, both spatulate and linear. Mostly jet-black insects with ornamental lines of silvery

scales on thorax and legs.—A genus of some 19 species, all with a smooth satiny appearance.

S. fasciata (*S. calopus*).—Thorax velvety-black to golden-brown, marked with two median straight and lateral curved lines, in the form of a lyre (or Jew's harp). Abdominal segments with snowy-white bands and lateral tufts. Proboscis pure black. Legs prettily banded (Fig. 8).

This is the most widely distributed mosquito of the family, being found throughout the entire tropical and subtropical zones, from the Hawaiian Islands to the Philippines, India, Egypt, Italy, Spain, the West Indies, Central and South Americas, and our southern States as far north as Virginia. Although of domestic habits and breeding freely in cisterns and tanks, it is also a good traveller on steamers and may be expected to establish itself in any moist tropical zone, a fact which should be borne in mind when much of our Asiatic trade passes through the Isthmus of Panama. It is the only known agent of transmission of yellow fever. That it is the only one cannot be asserted and does not seem probable, but it is a practical fact that campaigns against yellow fever based on that assumption have always been successful.

S. scutellaris of India, Siam and the Philippine Islands is very much like the preceding, but with only one median line in its thoracic lyre.

The larvæ of *Filaria* are said to occur in these two species of mosquitoes but unable to reach maturity.

3. **Mansonia.**—Wings with large, broad and asymmetrical scales.

M. uniformis.—Thorax chestnut-brown. Wings brindled but unspotted. Legs mottled and banded. Proboscis with broad yellowish band.—India, Africa and the Philippine Islands. This, and *M. pseudotitillans* of Brazil, are said to convey the larvæ of *Filaria.*

B. Subfamily **Anophelinæ.**—Soberly tinted insects, with palpi of about the same length as the proboscis in both sexes, usually clubbed in the male. In this subfamily are found all the mosquitoes concerned in the transmission of malaria. *Anopheles* is the only genus in this country, but the other genera here described occur in our colonies. Of the 15 or more species of **Anophelinæ** found in the Philippine Islands, 4 have been proved to be the hosts of the malarial parasite and to be responsible for most of the malarial fever there while at least three other species are open to suspicion.

1. **Anopheles.**—"Thorax and abdomen hairy. Palpi of females thin, generally unbanded. Wing veins with long lanceolate scales which may or may not form tufts, but rarely showing much color-spotting. Mostly large species from temperate or mountain climates."—Represented in the

United States by 9 or more species. Of the malarial mosquitoes of the Philippines and West Indies none belong to this genus.

The Anopheles is readily distinguished from Culex by the long palpi of the female which produce the appearance of three probosces. Its attitude when at rest is also characteristic, with body in a straight line but at an angle with the resting surface, head down and tail up, while the Culex, although more humpbacked, holds its body nearly parallel with the resting surface. The Anopheles lays only 40 to 100 eggs, more or less separated and not attached together like those of Culex. The eggs of the *maculipennis* are characterized by fine reticulate hexagonal sculpturing. The larvæ (wigglers) of both genera are also readily distinguished; that of Culex projects its breathing tube through the water surface and holds its body downward at an angle, while that of Anopheles holds its body parallel with the surface. The entire period covered by the metamorphosis of the *maculipennis*, from the laying of the egg to the escape of the insect, ranges between 12 to 20 days, being somewhat longer than that of our common *Culex fatigans*. The Anopheles is not particular as to breeding places, and may be found in any kind of clear or foul water, mixed up with Culex. It does not fear the movements of the water as much as the latter and shows a liking for green algæ and other aquatic plants.

The following are our noteworthy species:

A. maculipennis (Fig. 9).—Rather large but inconspicuous; easily recognized by the four small black spots on the wings, and the four golden stripes on the thorax. In the female the palpi are yellowish-brown, with dense dark scales at the swollen base, and shorter than the proboscis. Found almost everywhere in North America and Europe, and the common malarial mosquito of both continents. The only species which has been proved to be a host of the malarial parasite and to infect man.

A. occidentalis.—Western species closely allied to the preceding but distinguished by a yellow spot at the apex of the wing. Open to suspicion from its relationship.

A. punctipennis (Fig. 10).—Handsome insect with two brilliant yellow spots on the dark wing, one at the apex, the other larger, along the front margin. Very common in this country and Canada, but free from any imputation of transmitting malaria.

A. franciscanus.—Much like the preceding; the dark costa (edge) of the wing with two nearly equal yellow spots, and a pale spot at end of each vein of fringe. Found from California to Texas, and strongly suspected of conveying the malarial parasite.

A. crucians.—Dark, with silvery-tipped and banded palpi. Limited to the southern States and apparently harmless.

2. **Cycloleppteron.**—Wing with lanceolate scales, and patches of large inflated scales, densely pigmented, of almost circular outline.

C. grabhamii.—Small dark mosquito with sooty thorax and abdomen, and brindled legs; palpi very hirsute, almost to the tips. West Indian Islands where it has been accused of conveying malaria.

FIG. 9. FIG. 10.

FIG. 9.—Anopheles maculipennis, female. (*Manson.*)
FIG. 10.—Anopheles punctipennis, female, with male antenna at right and wing tip showing venation at left; much enlarged. (*Howard.*)

3. **Myzomyia.**—Thorax and abdomen hairy. Wings with long narrow scales projecting far apart; more or less spotted in contrasted colors.

M. funesta (*Anopheles funestus*) (Fig. 11).—Small dark mosquito, with three yellow spots on the intensely black costa (edge of wing), and spotted wing fringe; palpi with white tip and two snowy bands.—A host of the malarial parasite in Africa, and always taken in the Philippines wherever malaria is prevalent so as to leave no doubt of its guilt.

M. rossii (*A. rossii*).—A common species of India where it transmits filaria; also considered the malarial carrier in Ceylon; but too rare in the Philippines to be of importance.

M. ludlowii.—Small, with banded palpi and white-tipped proboscis;

legs mottled and spotted with yellow; wings with 4 large costal spots and one or two small basal ones.—One of the few mosquitoes breeding in salt water, being mostly found in tidal back waters. Widely distributed in the Philippines where it appears coincidently with malaria and, according to Banks and other observers, positively connected with its transmission.

M. indefinita.—Very closely related to the preceding two species, but without the leg spots of *ludlowii.* Also quite common in the Philippines but its connection with malaria is still doubtful.

Several other species of Myzomyia have been found carriers of the malarial parasite in India, and one in Brazil.

FIG. 11.

FIG. 12.

FIG. 11.—Myzomyia funesta (Anopheles funestus), female. (*Manson.*)
FIG. 12.—Myzorhynchus barbirostris (Anopheles barbirostris).

4. **Myzorhynchus.**—Abdomen without lateral scale tufts; wing scales broadly lanceolate, sometimes short and broad; palpi and proboscis bushy with densely packed scales.

M. barbirostris (*Anopheles barbirostris*) (Fig. 12).—Dark insect; wing intensely black, with a small apical spot; head and appendages entirely black except a white frontal tuft.—A host of the malarial parasite in India, and found in the Philippines coincidently with malarial fever; especially abundant at Siassi during the prevalence of the infection.

M. pseudobarbirostris, an allied species, may also be suspected.

M. sinensis, a host of the malarial parasite in Japan and China, as

been found at some of the stations in the Philippine Islands but its connection with malaria there is still doubtful.

Several other African and Indian species are also known agents of malarial and filarial infection.

5. **Nyssorhynchus.**—Thorax with narrow, curved and fusiform scales. Abdomen with lateral tufts and dorsal patches of flat scales. Palpi densely scaly. Legs banded and spotted white.

N. fuliginosus (*Anopheles fuliginosus*).—Small, very dark mosquito, with three yellowish spots on the black costa and numerous black dots on the veins, the last three tarsal joints of hind legs pure white.—Always appears in the Philippines in connection with malarial outbreaks and may be regarded as one of the transmitters of the parasite.

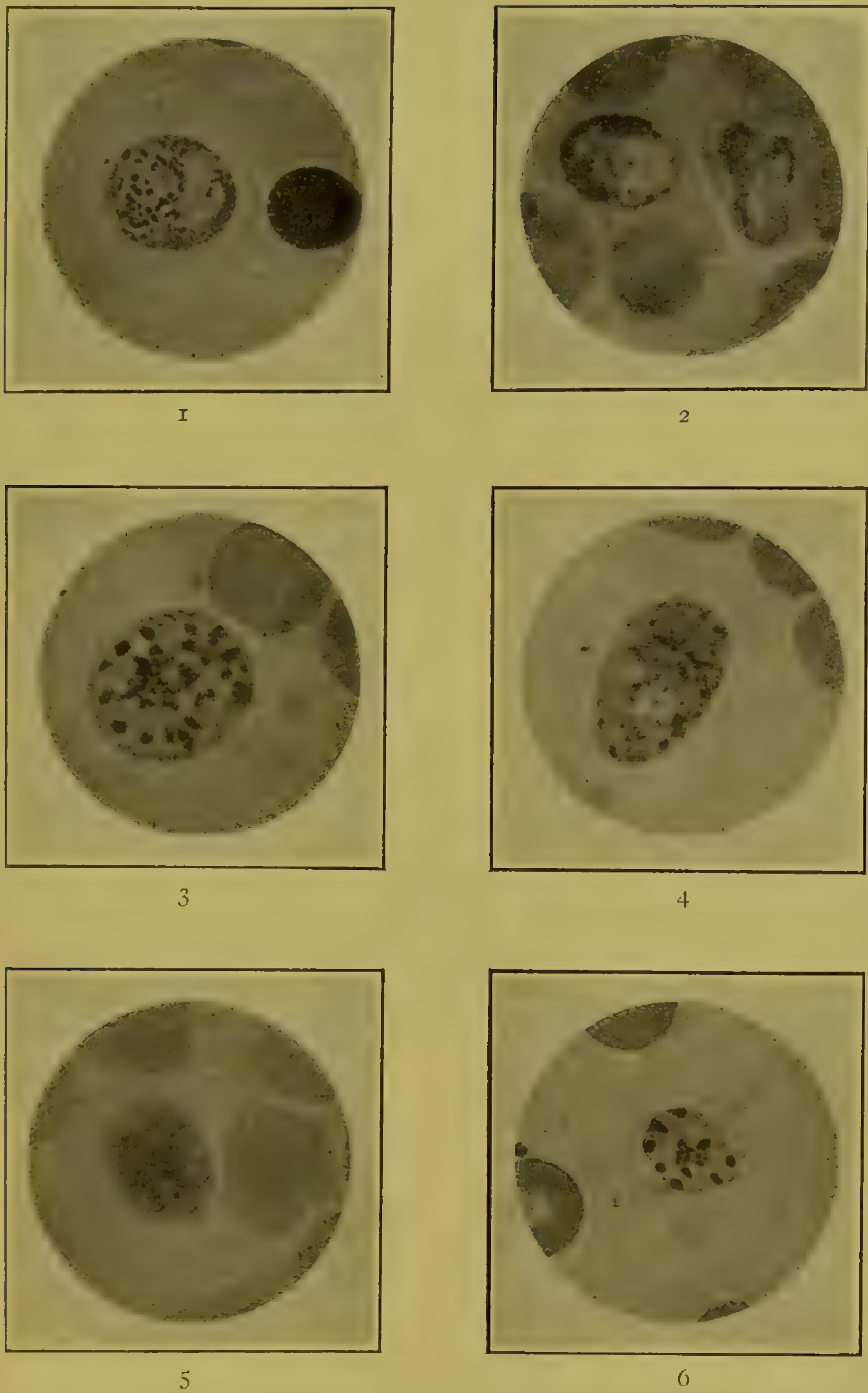
N. theobaldi, a host of the malarial parasite in India, has been found at a few stations in the Philippines but its connection with malaria there is still doubtful.

6. **Cellia.**—Abdomen almost completely but irregularly densely scaly, with large lateral tufts.—Handsome insects, among which are the best-known malarial carriers of the West Indies and Panama.

C. albimana (*Anopheles albipes*, *A. cubensis*).—Dark mosquito with the last three hind tarsal joints, and nearly half the second, pure white, save for a black band at base of the terminal joint.—"Certainly much the commonest Central American and West Indian anopheline, said to breed in canals, puddles, and in the most varied situations, even in brackish water" (Giles). It bites severely at any time of day and night. One of the usual hosts for the parasite of malignant malaria, and of *Filaria bancrofti*. It is inefficient for *Filaria demarquaii*.

C. argyrotarsis (*Anopheles argyrotarsis*).—Much like the preceding but not so dark, and without the black band at base of terminal tarsal joint. Also common in all the West Indies and further south, and likewise an efficient host and transmitter of the malarial parasite.

Another species is a common agent of malarial infection in Africa.



1. Tertian malarial blood showing full grown parasite (× 1000).
2. Tertian malarial blood showing ameboid forms of parasite (× 1500)
3. Tertian malarial blood showing segmenting parasite (× 1500).
4. Tertian malarial blood showing sexual form (× 1500).
5. Quartan malarial blood showing band form of parasite (×1500.
6. Quartan malarial blood showing segmenting parasite (× 1500)

CHAPTER V.

INFECTIOUS DISEASES (Continued).

MALARIA.

Malarial fever, intermittent fever, ague, chills and fever, are different names for the same disease. Formerly ubiquitous in the inhabited parts of the United States, it has of late years lost much of its importance and is still steadily decreasing in prevalence and severity, so that among the diseases which most affect soldiers at home it is fifth in the number of admissions, with rate of 47.31 per thousand of strength, and only 2

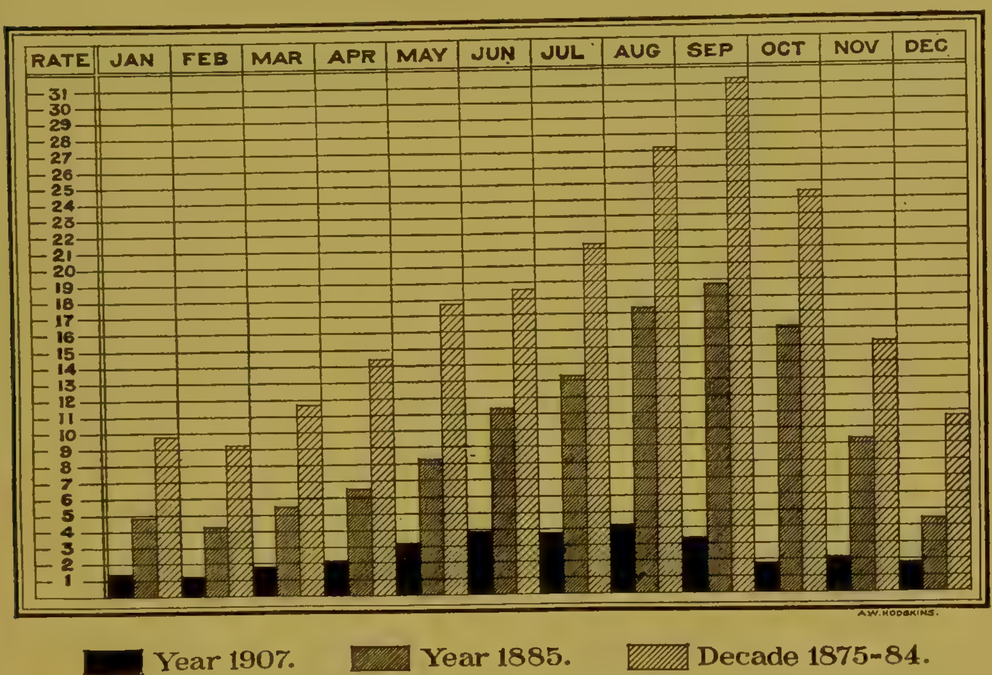


FIG. 13.—Diagram illustrating the distribution of cases of malarial fever by months per thousand strength, in the United States Army at home. Also showing their constant reduction.

deaths for the years 1904–06 (Fig. 13). Unfortunately, malaria still prevails, under severe types, in our colonial possessions, being one of the principal causes of death in the Philippines and, next to venereal diseases, the principal cause of admissions and non-effectiveness. This is explained by the necessity, until lately, of frequent movements of troops precluding the application of the usual preventive measures for a sufficient period of time. A vigorous campaign against mosquitoes is now

carried on and it may be confidently assumed that the rates of malarial fever in our colonies will soon show very marked improvements.

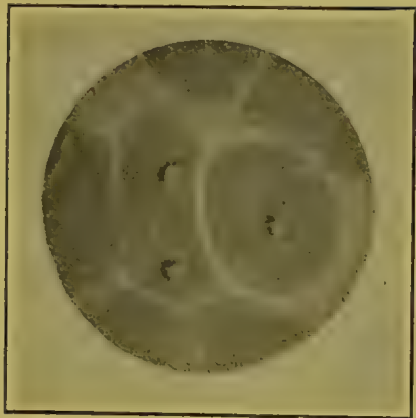
Malaria is an Italian word meaning bad or poisonous air from the belief that the disease was caused by emanations from the soil. It is now generally recognized that it results only from the biting of certain species of mosquitoes, and that soil or water are not directly concerned in its etiology.

Parasite.—In the act of stinging, while sucking blood, the mosquito injects saliva into the puncture and, if infected, the germs or parasites of malaria are carried along with the saliva. These parasites are microscopic animalcules, of the class sporozoa, found in the red blood-cells. They were described by Laveran, in 1880, but the first definite mosquito-malaria theory was formulated by Manson in 1894.

It is generally accepted that each form of malaria is produced by a distinct variety or species of parasite. The various species are generally divided into two groups, the benign and the malignant. The benign parasites (*Plasmodium*) are two: the *quartan parasite*, having a cycle of 72 hours in the human body and causing a fever recurring every 3 days, and the *tertian parasite*, with a cycle of 48 hours causing a fever recurring every 2 days. They are morphologically distinguished by not forming crescents, and, clinically, by comparatively mild types of fever, easily controlled by quinine. The malignant parasites (*Laverania*) are at least three: the *subtertian* (æstivo-autumnal) with cycle of approximately 48 hours; the *pigmented quotidian* and the *unpigmented quotidian*, both with cycle of approximately 24 hours. They are very much smaller than the benign parasites, frequently causing the invaded blood-cells to become shrivelled and crenated and to assume a dark "brassy" color, but are chiefly distinguished by their assuming the shape of crescents. Clinically, they give rise to fevers of very irregular course and often of pernicious type over which quinine has but little effect.

Whatever its species, the parasite exhibits two distinct phases or cycles, one inside the human body and one in the body of the mosquito, both cycles being necessary to its full sexual development and perpetuation.

Human cycle.—If the blood is examined microscopically shortly after a malarial paroxysm (Fig. 14), some cells may be found containing the young parasite, in the form of an ill-defined, pale, roundish body showing active movements; scattered through it are fine granules of reddish-black pigment (f, g); after a while these granules collect into groups or lines (h, i, j, a); still later, the body of the parasite, which fills the cell, divides into segments which become well-defined spherules arranged, rosette-like,



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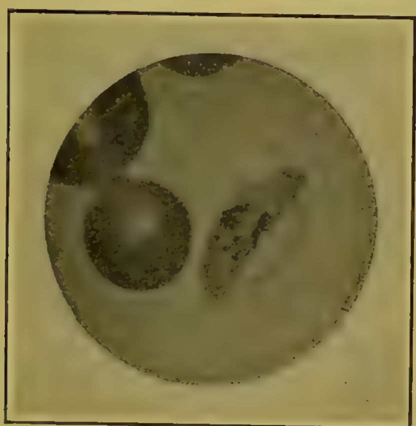

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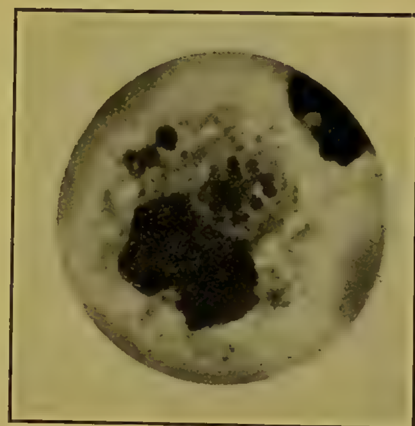

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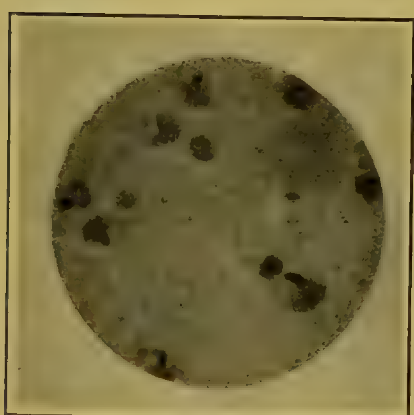

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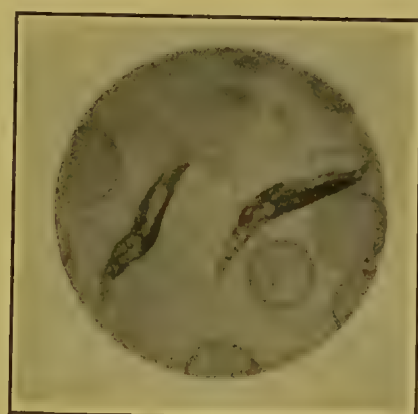

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1. Æstivo-autumnal malarial blood showing ring forms of parasite (× 1500).
2. Æstivo-autumnal malarial blood showing segmenting parasite (× 1500).
3. Æstivo-autumnal malarial blood showing crescent (× 1500).
4. Æstivo-autumnal malarial blood showing segmenting parasite in leucocyte (× 1500).
5. Parasite of kala-azar in splenic pulp (× 1500).
6. *Trypanosoma lewisi* in blood of rat (×1500).

around the pigmented center (b). The blood-cell now breaks down and the spherules become free in the liquor sanguinis (c, d). It is at this time that the chill, or first stage of the attack, takes place, due probably, not so much to the presence of the spherules as to that of some toxin set free in the circulation. Most of the spherules are absorbed and devoured by the white cells (phagocytes) but some escape, attach them-

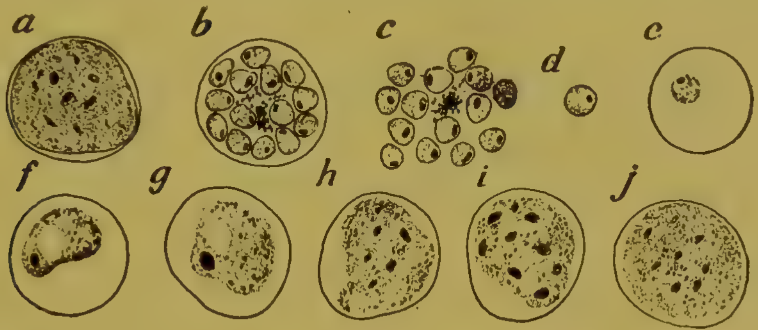


FIG. 14.—Evolution of the tertian parasite, stained. (*Manson.*)

selves to other red blood-cells which they contrive to enter (e), and begin another cycle of life. The malarial parasite, thus exposed to the attacks of the white cells of the blood and other enemies, would soon disappear from the human body, and out of existence, did it not have means of propagating itself outside the body and reentering it afterward.

It has been seen that the parasites, in reaching maturity, develop into rosette-like or segmenting bodies, but not all of them; some develop into

FIG. 15.—Evolution of the flagellated body from the crescent (*Manson*).

the sexual forms or *gametes*. The gametes are spherical in benign fevers, looking like ordinary large intracellular pigmented parasites, and crescent-shaped in the malignant fevers. The latter are of slow development and found only after a week or ten days of malarial infection; they are readily distinguished by their shape, their pigmented center and the convex line bridging over the concavity (Fig. 15, a). In the human body

the gametes do not proceed any further in sexual development. The spherical gametes seldom last long, while the crescents may persist for months, sometimes disappearing from the superficial circulation but generally numerous in the deeper viscera.

Mosquito cycle.—When blood containing gametes (spheres or crescents) has been sucked by certain species of mosquitoes, further changes soon take place. The crescents become transformed into spheres. The spheres from either source, benign or malignant, can now be differentiated into two kinds, male and female. The former are transparent or hyaline, the latter are filled with granular protoplasm. In the male sphere, one or more filaments or flagella (*microgametes*) suddenly grow out from the periphery. These flagella execute characteristic waving and lashing movements and often succeed in breaking loose from the sphere. Each flagellum thus set free enters and impregnates a granular or female sphere (*macrogamete*). The latter soon changes shape, becomes pointed and vermicular and moves about with great vigor. It finally lodges in the walls of the mosquito's stomach where it increases in size. Its nucleus and protoplasm divide into a number of spherular cells around which spindle-shaped, spine-like bodies are formed. These bodies or "sporozoites" become loose in the capsule and are discharged into the stomach. Thence they find their way, through the blood circulation, to the 3-lobed salivary glands lying one on each side of the forepart of the thorax, and, as stated before, are injected, with the saliva, into the animal bitten by the mosquito.

It appears, from what has been said, that the malarial parasite undergoes important changes when passing from one host to the other, and is not infective until these changes are completed. Thus a man bitten by an infected mosquito does not develop symptoms of malaria until a week or ten days afterward, and probably does not become infectious to another mosquito for several days later. The mosquito which has become infected by sucking the blood of a malarial patient is not dangerous until the lapse of about ten days, or until the sporozoites have matured and been conveyed to the salivary glands.

Prophylaxis.

This may be considered under the following heads:

1. Destruction of mosquitoes.
2. Protection against mosquito bites.
3. Isolation and protection of malarial patients.
4. Medical prophylaxis.

The first three means of prevention are entirely based on our knowledge of the rôle played by the mosquito in the genesis of malarial fever. Not only the first, but the second and third as well, if carried out singly with completeness for a couple of years, would eliminate malaria. Thus were all healthy men protected against mosquitoes, no new cases of infection would be possible; likewise, were all malarial patients so protected that no mosquitoes could get at them and become infected, the disease would necessarily come to an end. But it is evident that much better and quicker results can be obtained by a combination of these means.

1. *Destruction of mosquitoes.*—This is sometimes possible, in one or two seasons, by intelligent concerted action between individuals, or with adequate financial means provided by State or municipality and expended under the supervision of experts. Generally, complete extinction, in civilized countries, is only the result of steady and progressive cultivation and drainage for a period of years. But, fortunately, long before such result is obtained, in temperate climates, malarial fever will have practically disappeared; that is to say, that the chances of a reduced number of mosquitoes becoming infected from a coincidently reduced number of malarial cases, soon become quite remote. There is therefore, for each place, what may be called a minimum of safety, depending upon the amount of infective material accessible; for instance, two or three anopheles mosquitoes in a Filipino village, a majority of whose natives carry the germs of malaria, are much more dangerous than swarms of them in a New England town.

Only certain species of mosquitoes convey malaria or are suspected of doing so. Therefore it is important to ascertain, in each locality, whether those species are present and, if so, to study their habits and places of breeding. As a rule, however, different species, innocent and guilty, will be found breeding together under the same circumstances so as to make it difficult and often impossible to discriminate between them in our warfare.

Mosquitoes cannot breed unless they have water wherein to lay their eggs. Hence the accepted axiom: no water, no mosquitoes. This water must be relatively still; no running or ruffled water will do. The first measure then which imposes itself is the drainage of all surrounding swamps and stagnant pools. But within the boundaries of a post or camp, swarms of mosquitoes may be produced from sewers, cisterns, tanks, pits and cesspools, water barrels, neglected buckets and tin cans. Therefore, before blaming the neighboring grounds it is always judicious to make a careful investigation of the military reservation and exclude therefrom all possible breeding places. Pits and holes should be filled up.

4

All receptacles likely to hold rain-water should be broken up or turned bottom up. Barrels and cans in which water must be kept should be covered with a well-fitting lid. Tanks and cisterns, if not roofed over and mosquito-tight, should be protected with wire screens. Pools and ponds which cannot be drained or filled up should have a thin film of kerosene or petroleum poured upon the surface, or sprayed with a nozzle, at the rate of one ounce to each 15 square feet, once every two weeks. This "petrolization" is easy, cheap and quite effective; not only does the film of oil prevent the female mosquito from laying eggs, but all the larvæ already in the water, unable to breathe through it, promptly perish. The best oil for the purpose is one which spreads readily but does not evaporate too rapidly, the "light fuel oil" of trade. To kill larvæ in pools under houses or difficult of access, salt can be used or a strong solution of copper sulphate. An aniline product called "larvicide" is highly recommended by Celli; it acts as a poison, killing all larvæ within a few hours in a strength of 1:7000, and is said not to be injurious to plants, cattle or man. Ponds and lakes will be sufficiently protected if well stocked with fish, especially species of top-minnows (Gambusia), sticklebacks and sunfish, all voracious feeders and particularly fond of mosquito larvæ.

2. *Protection against mosquito bites.*—In a malarial country, or wherever mosquitoes are prevalent, the mosquito-bar is indispensable. To be effective, it must be sufficiently long to rest upon the floor all round the bed, and its meshes sufficiently small, at least 14 to the inch, to exclude young mosquitoes. A 16- to 18-mesh bobbinet bar is now supplied to each man in the United States Army, especially in the Philippines. A hole or tear in a bar makes it worse than useless, for mosquitoes will get in and be caught as in a trap, unable to escape. The careful use of the bar should be the subject of strict disciplinary measures.

In countries where malarial or other mosquito-borne diseases prevail, or are apprehended, thorough prophylaxis requires also that, so far as practicable, all doors, windows, ventilators, etc., should be screened with wire netting (bronze or copper wire), so that mosquitoes may not get inside of buildings. There are few barracks or other large inhabited structures, however, especially in the tropics, which can be so completely screened as to be mosquito-tight and render mosquito-bars unnecessary. Such result is obtainable only when the architect plans and builds with this end in view. All the new buildings in the Isthmian Canal Zone, for instance, are so constructed as to admit of complete screening, and it has been shown that this can be accomplished without sacrificing any of the requisites of air space and ventilation (Fig. 16).

Whenever a building or room has become invaded by mosquitoes, or there is reason to believe that is contains one or more infected ones, the quickest way to get rid of them is by fumigation. The easiest method is the burning of pyrethrum powder, 2 pounds to each 1,000 cubic feet of space, but the insects are simply stupefied and must be swept up and burned lest they revive. Campho-phenol is more effective. (see p. 445). Sulphur is the best insecticide and can always be relied upon when its use is not otherwise contraindicated. Formaldehyde, although an efficient disinfectant, has no value as an insecticide.

FIG. 16.—Club-house at Culebra, Panama, showing construction for thorough screening against mosquitoes.

In a malarial country and so long as mosquitoes are about, the soldier should be protected not only in garrison but also in camp and in the field. Under these circumstances he should be supplied with a mosquito-bar, as part of his equipment, just as certainly as he is with a blanket and shelter-tent. The ordinary mosquito-bar should be modified along the lines indicated by Captain Vedder, Medical Corps, so as to fit not only the bunk and the cot but also the shelter-tent (Figs. 17 and 18).

3. *Isolation and protection of malarial patients.*—As soon as a man suffers from febrile symptoms which may be reasonably ascribed to malaria, he should be isolated and protected, that is to say, placed in a screened ward, under a mosquito-bar, so that no mosquito can have access to him. Should the development of the case prove it to be not malarial, nothing will be lost by these preliminary measures.

Unfortunately, it is well known that the natives of malarial districts, especially in tropical countries, become more or less immune to the disease and that, although their blood contains the parasite, they enjoy a fair degree of health, and attend to their usual daily occupations. In certain parts of the Philippines, and in the Isthmus Canal Zone, more than half of the natives were found thus infected, although not apparently incapacitated for work. These immune natives are a constant and widespread menace to other people, especially young soldiers. In and about their quarters infected mosquitoes are always found, so that to visit them,

FIG. 17.—The Vedder mosquito-bar for use with shelter tent.

especially when these insects are most active, in the evening or during the night, is to court serious danger. Such visiting should be strictly prohibited. For this and other reasons which suggest themselves, a camp, other things being equal, should never be pitched in the immediate vicinity of native villages.

From what precedes it may be deduced that the prophylaxis of a post or camp, in a malarious district, involves likewise that of the surrounding communities; much can be done in that direction by education so as to secure the cooperation of all concerned and develop an appreciation, even by the poor and ignorant, of the advantages of screening, mosquito-bars and quinine.

Medical prophylaxis.—Two medicines have been recommended as preventives of malaria, arsenic and quinine. The prophylactic virtue of arsenic is very doubtful and the drug is now seldom used for the purpose. Quinine is a well-known specific as curative and preventive. Its systematic use when campaigning in malarious districts will always considerably reduce the number of admissions. It should be supplementary to other means of prophylaxis, especially the use of the mosquito-bar, and not

FIG. 18.—The Vedder mosquito-bar suspended from ridge of shelter tent.

take their place. The best methods of administration are: 5 grains every day after breakfast, Saturday and Sunday excepted, or 10 grains twice a week.

As it is very probable that the immunity of natives in malarious districts is acquired at the expense of a certain amount of energy and vitality, it would be clearly to their advantage and that of all people having intercourse with them, should they be subjected to a sufficiently prolonged course of quinine to get rid of the infectious parasite and cease to be a menace to their neighbors.

BLACKWATER FEVER (HEMOGLOBINURIC OR HEMATURIC FEVER).

An acute disease characterized by an initial chill, fever, bilious vomiting, jaundice and hemoglobinuria. The urine becomes very dark, sometimes almost black and, as the paroxysm subsides, returns gradually,

through shades of red, to its normal color. It is frequently diminished in quantity and sometimes suppressed. The fever may be intermittent, remittent or continued.

It is found in many tropical and subtropical countries, as well as in our southern States, and, as a rule, is most prevalent in malarial regions. Until recently it was considered an unusually severe form of malaria, or the result of large doses of quinine, but Sambon and Manson are now inclined to regard it as a distinct disease, caused by some blood protozoön (probably *babesia*) which hitherto has escaped the search of the microscope. Whether the mosquito is its transmitting agent has not been determined.

Since blackwater fever is mostly observed in individuals who have, or have had, malaria, prophylaxis should consist in avoiding exposure to the causes of malaria, or, if infected, in taking quinine systematically and continuously.

YELLOW FEVER.

The home of this dread disease appears to have always been the central portion of the American Continent, and more especially the West Indies. From such endemic foci as Vera Cruz, Havana, Kingston and Panama it has been carried southward as far as Buenos Ayres, and along the Pacific coast from Mexico to Peru. It has also occasionally visited the western European countries and the coast of Africa. Most of the Gulf and Atlantic seaports of the United States, as far north as Providence, have been repeatedly scourged by it, New Orleans and Philadelphia being the two greatest sufferers. This disease caused fearful loss of life in all the military expeditions to the West Indies during the last two centuries and compelled the English, after their conquest of Havana, in 1763, to return that city to the Spaniards in exchange for Florida

Etiology.—The mode of transmission of yellow fever was unknown until the year 1900, when a commission of medical officers from the United States Army, consisting of Reed, Carroll, Agramonte and Lazear, appointed to investigate tropical diseases, made one of those brilliant discoveries which mark epochs in the progress of medical science. They proved that yellow fever cannot be contracted by contact with the patient or his effects; that it is not conveyed through the air nor through food or drink, but that it is always the result of mosquito bites. They supported their doctrine with such convincing demonstrations and arguments that, in spite of strong and prejudiced opposition, it was promptly

accepted by the scientific world. So far as now known, yellow fever is transmitted by only one species of mosquito, *Stegomyia fasciata* (page 40). This mosquito, to be infected, must bite a patient during the first three days of the disease, and it cannot transmit the infection until the lapse of at least 12 days after the bite. The subcutaneous injection of blood, or blood serum, from a yellow-fever patient, into a non-immune person, will also cause an attack within the usual incubation period.

The nature of the specific virus transmitted from patient to mosquito, and from the latter to non-immunes, remains unknown. Whether it is a soluble toxin, a bacterium or protozoön has not been determined, although the indications strongly favor the protozoön theory. However, if it be an organism, vegetable or animal, it is so tenuous as to be ultra-microscopic, beyond the power of our best microscopes. It has been proved that blood serum from a yellow-fever patient is capable of conveying the disease by subcutaneous injection, therefore contains the specific virus, even after being passed through a Berkefeld filter which excludes all visible microbes.

The propagation of yellow fever obviously requires three conditions: preexisting cases of the disease, stegomyia mosquitoes and the presence of non-immunes. If there is no yellow fever in the locality, everything else may be disregarded. If in a town with good sanitary service there are but few cases, properly isolated, while, on the other hand, the Stegomyia mosquitoes are not common, the danger is a negligible quantity.

Prophylaxis.—Our full knowledge of the mode of transmission of yellow fever has robbed this disease of its terrors and made its prevention a comparatively simple matter. It has already disappeared from Cuba, Vera Cruz and Panama and we may reasonably assume that it will be practically stamped out from the continent before many years have elapsed.

The rules to be followed suggest themselves; it is mostly a question of their strict and efficient application. As in the case of malaria, every effort must be made to destroy the mosquitoes or at least reduce their number. The Stegomyia is a domestic insect, therefore tanks and cisterns should be protected against it, and water not allowed to stand in gutters, spouts, tubs, vases and other receptacles in or about dwellings. It is a twilight mosquito, feeding early in the morning, and in the afternoon and evening until ten o'clock, so that non-immunes can go about in infected localities between 9 A. M. and 3 P. M. with almost absolute impunity (Carroll). Houses should be screened, so far as it is practicable,

and all inmates sleep under efficient mosquito-bars. As soon as any person (especially if non-immune), in an infected locality, experiences symptoms of fever not readily accounted for, particularly if it begins with a chill and headache, he should at once be isolated and placed behind wire screens and mosquito-bar. Since the patient is only infectious to the mosquito during the first three days of the disease, the necessity of discovering and promptly isolating him, in the incipient stage, becomes clearly apparent. As soon as he is removed from his room, and before mosquitoes have a chance to escape, disinfection must follow. As the only pathogenic germs are in the bodies of infected mosquitoes, the sole object of this disinfection, or rather fumigation, is to destroy all mosquitoes in the patient's bedroom and adjacent rooms and thus remove the only cause of further danger. For this purpose, the fumes of pyrethrum powder, campho-phenol or sulphur are used, as described in another chapter. The disinfection of the patient's person, bedding, clothing and effects, is entirely unnecessary.

The natives of zones where yellow fever is endemic are immune to it. This is attributed to the effect of a mild form of the infection which they are supposed to have had in infancy and childhood, the so-called *borras fever* of the Cubans. All non-immunes, in an infected locality, should be identified, brought together as much as possible, regularly inspected and the object of special sanitary measures.

From the day a man is taken sick, no secondary case can result before the lapse of at least 14 days, namely, 1 day or more before the secondary mosquito becomes infected, 12 days for the elaboration of the germ in its body, and 1 or more days of incubation after biting the secondary patient. Therefore if, in an outbreak, after a lull of 2 or 3 weeks, a new crop of cases appears, the presumption is very great that the mosquitoes infected by the primary crop, or some of them, are still at large.

The incubation of yellow fever ranges usually from 3 to 4 days, so that a quarantine period of at least 5 days is necessary. Any person suspected of having been exposed to the bite of infected mosquitoes should be kept under observation until 5 days have elapsed. Ships visiting infected ports should keep away from other vessels and anchor at least one-fourth of a mile from shore.

As soon as the experiments of the Army Board in Havana had definitely established the rôle of the mosquito in the propagation of yellow fever, the following circular prepared by the writer, then chief surgeon of the Island of Cuba, was promulgated. It was the first official recognition and application of this great and far-reaching discovery.

CIRCULAR, }
No. 5. }

HEADQUARTERS DEPARTMENT OF CUBA,
Havana, April 27, 1901.

Upon the recommendation of the chief surgeon of the department, the following instructions are published and will be strictly enforced at all military posts in this department:

The recent experiments made in Havana by the Medical Department of the Army having proved that yellow fever, like malarial fever, is conveyed chiefly, and probably exclusively, by the bite of infected mosquitoes, important changes in the measures used for the prevention and treatment of this disease have become necessary.

1. In order to prevent the breeding of mosquitoes and protect officers and men against their bites, the provisions of General Orders No. 6, Department of Cuba, December 21, 1900, shall be carefully carried out, especially during the summer and fall.

2. So far as yellow fever is concerned, infection of a room or building simply means that it contains infected mosquitoes, that is, mosquitoes which have fed on yellow fever patients. Disinfection, therefore, means the employment of measures aimed at the destruction of these mosquitoes. The most effective of these measures is fumigation, either with sulphur, formaldehyde or insect powder. The fumes of sulphur are the quickest and most effective insecticide, but are otherwise objectionable. Formaldehyde gas is quite effective if the infected rooms are kept closed and sealed for two or three hours. The smoke of insect powder has also been proved very useful; it readily stupefies mosquitoes, which drop to the floor and can then be easily destroyed.

The washing of walls, floors. ceilings and furniture with disinfectants is unnecessary.

3. As it has been demonstrated that yellow fever cannot be conveyed by fomites, such as bedding, clothing, effects and baggage, they need not be subjected to any special disinfection. Care should be taken, however, not to remove them from the infected rooms until after formaldehyde fumigation, so that they may not harbor infected mosquitoes.

Medical officers taking care of yellow fever patients need not be isolated; they can attend other patients and associate with non-immunes with perfect safety to the garrison. Nurses and attendants taking care of yellow fever patients shall remain isolated, so as to avoid any possible danger of their conveying mosquitoes from patients to non-immunes.

4. The infection of mosquitoes is most likely to occur during the first two or three days of the disease. Ambulant cases, that is, patients not ill enough to take to their beds and remaining unsuspected and unprotected, are probably those most responsible for the spread of the disease. It is therefore essential that all fever cases should be at once isolated and so protected that no mosquitoes can possibly get access to them until the nature of the fever is positively determined.

Each post shall have a "reception ward" for the admission of all fever cases and an "isolation ward" for the treatment of cases which prove to be yellow fever. Each ward shall be made mosquito-proof by wire netting over doors and windows, a ceiling of wire netting at a height of seven feet above the floor, and mosquito-bars over the beds. There should be no place in it where mosquitoes can seek refuge not readily accessible to the nurse. Both wards can be in the same building, provided they are separated by a mosquito-tight partition.

5. All persons coming from an infected locality to a post shall be kept under careful observation until the completion of five days from the time of possible infection, either in a special detention camp or in their own quarters; in either case, their temperature should be taken twice a day during this period of observation so that those who develop yellow fever may be placed under treatment at the very inception of the disease.

6. Malarial fever, like yellow fever, is communicated by mosquito bites and therefore is just as much of an infectious disease and requires the same measures of protection against mosquitoes. On the assumption that mosquitoes remain in the vicinity of their breeding places, or never travel far, the prevalence of malarial fever at a post would indicate want of proper care and diligence on the part of the surgeon and commanding officer in complying with General Orders No. 6, Department of Cuba, 1900.

7. Surgeons are again reminded of the absolute necessity, in all fever cases, to keep, from the very beginning, a complete chart of pulse and temperature, since such a chart is their best guide to a correct diagnosis and the proper treatment.

BY COMMAND OF MAJOR GENERAL WOOD:

H. L. SCOTT,

Adjutant-General.

DENGUE.

Dengue, or break-bone fever, is an acute infectious epidemic disease of tropical and subtropical countries. It has frequently prevailed in the Southern States, as far north as Charleston, and occasionally reached Philadelphia and New York. Its mortality is very small, in uncomplicated cases practically nil.

There has been no case of dengue among troops in the United States during the last few years, but the disease is more or less endemic in the Philippine Islands and one of the important causes of admission, the annual rate for the period 1904–6 having been about 60 per thousand of strength. No death from it.

Dengue presents much analogy to yellow fever in some of its peculiarities; it only prevails in warm weather, always ceasing with the advent of winter in the southern States, and spreads most readily along the coast line, seldom extending far inland, or upward to a high altitude.

Nothing definite is known regarding the virus of this disease but its mode of propagation seems to have been finally settled by the experiments of Ashburn and Craig (The Military Surgeon, September, 1907) whose conclusions are as follows: No organism, either bacterium or protozoön, can be demonstrated in either fresh or stained specimens of dengue blood under the microscope; the intravenous inoculation of unfiltered or filtered blood into healthy men is followed by a typical attack of the disease; the disease can be transmitted by the mosquito *Culex fatigans* and this is probably the more common method of transmission; the period of incubation in experimental cases averaged 3 days and 14 hours.

Bancroft, in Australia, also concluded that the germ is ultramicroscopic, but that it was conveyed by *Stegomyia fasciata.*

Trypanosomiasis, or Sleeping Sickness, is the name of the disease caused by *Trypanosoma gambiense,* a blood protozoal parasite common in Africa and supposed to be transmitted by the tse-tse fly. **Kola-Azar,** a highly fatal disease, caused by a peculiar protozoal parasite in the blood (Leishman body), prevails in India and other parts of Asia. Neither of these diseases has as yet been encountered in the Philippine Islands.

MALTA FEVER.

A continued fever of low mortality, having its home in Malta and other islands of the Mediterranean, but occurring sporadically in most tropical and subtropical countries, including the Philippine Islands. It is caused by the presence in the blood of the *Micrococcus melitensis* which enters the body by way of the alimentary canal, therefore through infected food or drink. In Malta and other islands, the disease has been found to be propagated mostly through the milk of infected goats.

TYPHUS FEVER.

An acute, very infectious epidemic disease, as yet of unknown origin, formerly causing, as already stated, a fearful mortality in many parts of Europe, especially in camps and along trails of armies. Outbreaks have been rare in the United States and easily controlled, always resulting from imported cases. The disease is still endemic in several countries, especially Great Britain, Ireland and Russia. The last extensive outbreak of it was in the Turko-Russian War in 1878, but many sporadic cases were found in most of the Russian base hospitals during the Russo-Japanese War.

We are still ignorant of the cause of the disease, of the form in which the virus leaves the patient and how it gains access to the body of healthy

individuals. It is quite probable, however, that the respiratory tract is the portal of entry, for experience has proved that the most successful prophylaxis consists in giving the patients plenty of fresh air and the benefit of thorough ventilation.

RELAPSING FEVER.

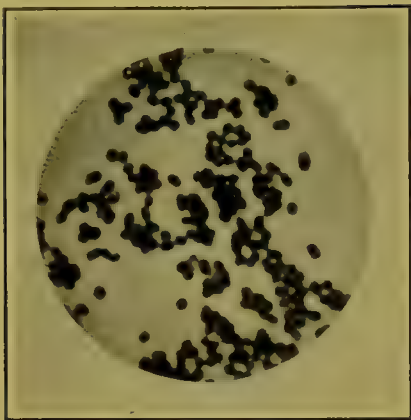
An infectious disease usually occurring in epidemics, characterized by second and third attacks after periods of remission. Formerly common all over Europe and Asia, but there have been few epidemics of it in this country where it never showed any tendency to spread. It is still endemic in the Philippines although no cases have so far been reported among our troops. Like typhus, it is a disease of poverty, overcrowding and insanitary conditions, but its mortality is small.

The specific cause is a *spirochæte* (*spirillum* of Obermeier), apparently conveyed from one individual to another by blood-sucking insects, such as ticks, bedbugs, etc.

PLAGUE.

Bubonic plague is an acute infectious disease with rapid and severe course and great mortality. Formerly one of the worst scourges of the Old World, it is now rarely seen in Europe and America but still endemic in many parts of Asia as well as in the Philippines. It is caused by the *Bacillus pestis* of Kitasato, an organism likewise pathogenic to nearly all animals. In infected districts, plague prevails extensely among rats which, in turn, infect the numerous fleas feeding upon them. The bite of these fleas, as well as the direct transmission, by flies or otherwise, of the patient's secretions or excretions through an abrasion or minute wound of skin or of mucous membrane, may produce the disease. Bacilli introduced into the stomach are mostly harmless.

The prophylaxis consists chiefly in good sanitation. Plague thrives in filthy places, while it seldom attacks people living in clean surroundings. The greatest risk always threatens bare-footed and bare-legged people. In an exposed community, a rigorous quarantine of at least ten days should be maintained against all suspected ships, even at the risk of serious interference with business, for when plague has secured a foothold it is exceedingly difficult of eradication. Every effort should be made to recognize and isolate the first cases. All patients must be removed to a special hospital and their homes placed in quarantine. Infected houses and all their contents are to be thoroughly disinfected, at the same time that a war of extermination is waged against all animals likely to convey the infection, especially rats, mice, fleas and flies.



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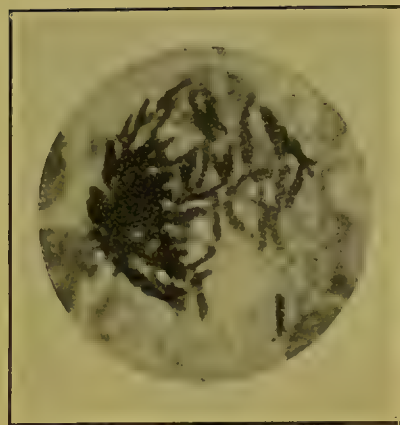

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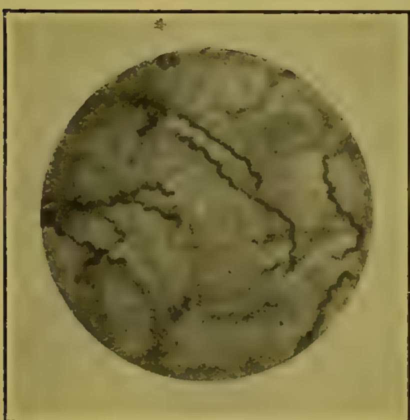

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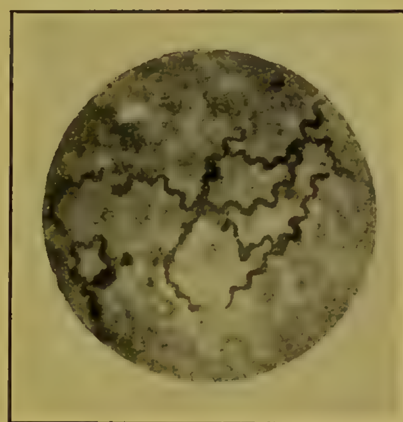

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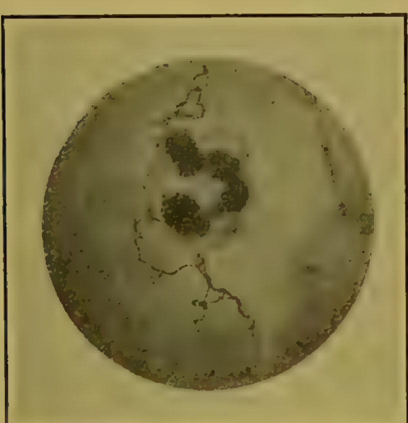

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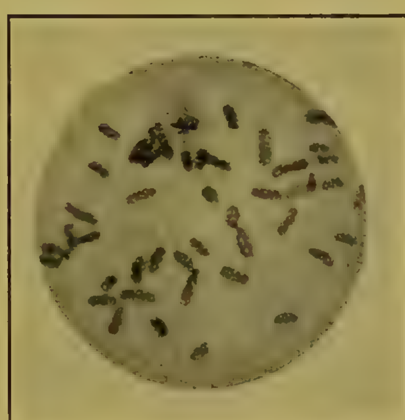

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1. Diplococcus of cerebro-spinal meningitis in pure culture (× 1500).
2. Bacillus of leprosy in section of skin (× 1500).
3. *Treponema pallidum* of syphilis in chancre (× 1500).
4. *Treponema pertenue* of yaws in section of skin (× 1500).
5. Spirochæte of relapsing fever in blood of monkey (× 1500).
6. Bacillus of plague in smear from spleen (× 1500).

LEPROSY.

A widespread chronic infectious disease, most common in China, India and Japan but found in nearly all countries, including the United States and its colonies. The *Bacillus lepræ* is accepted as the cause, but the manner of its introduction into the body and the conditions favoring it are still uncertain. It seems probable that the infection is by inhalation of the bacillus, especially through the nasopharynx, as the result of prolonged and intimate association with patients. Prophylaxis consists in segregation and isolation of patients.

EPIDEMIC CEREBROSPINAL MENINGITIS.

An acute infectious disease with special lesions of the meninges of the brain and cord. Common in Europe and America, but chiefly at home in this country where it causes a notable proportion of the yearly mortality in crowded and unsanitary districts. Among our troops, in the United States, small outbreaks occur every year, with a mortality of over 50 per cent. (14 deaths during the period 1904–6).

The accepted cause, in the epidemic and sporadic forms, is a double coccus, *Diplococcus intracellularis meningitidis* of Weichselbaum, found not only in the involved tissues but also in the secretions from the mouth, nose and conjunctiva. The method by which it gains access to the cranial cavity is a matter of speculation, probably by inhalation, through the mucous membrane of the nose and pharynx. It has been ascertained that it may be present in the nasal mucus of a healthy person without producing the disease, although capable of communicating it.

The prophylaxis consists in the isolation of patients, with sufficient air space and ventilation, and all other measures tending to prevent the contamination of the air with the oral and nasal secretions.

BERI-BERI (KAKKE).

An acute or chronic infectious disease characterized by disturbances of circulation, motion and sensation. Very common in Japan and China and, to a much lesser extent, prevalent in most tropical and subtropical countries. It was the disease which most disabled the Japanese troops in the late Russo-Japanese War.

The specific virus has not yet been definitely ascertained nor its mode of introduction into the body. The contention that the disease results from an exclusive rice diet, or non-nitrogenous food, appeared for a while to be a well-grounded assumption, but later observations have proved that the food is not directly concerned in its etiology. For instance, in the

Filipino village, at the St. Louis Exposition, 59 of the inmates of an overcrowded building developed beri-beri, while the inmates of the other quarters, all fed on the same liberal rations, did not have a single case. Likewise, during the visit of several Brazilian warships to the Jamestown Exposition, beri-beri broke out aboard one of them, with a total of 20 cases in June and July, while not a single case occurred on the other ships where, presumably, the same food was served. Experience has frequently demonstrated that beri-beri is but little affected by diet alone but responds quickly to a general improvement of all hygienic conditions. It is apparently a place infection and its direct transmission from an individual to another has never been satisfactorily proved.

YAWS (FRAMBŒSIA).

Yaws is a highly contagious, inoculable chronic disease characterized by mild constitutional disturbance and eruptions of fungoid incrusted tubercles. Common in Africa, the West Indies and parts of India. Not rare in some of the Philippine Islands among the very poor and ignorant, but seldom seen in Manila. The causative agent is a minute, spirally-twisted organism or spirochæte, the *Treponema pertenue* of Castellani, which so closely resembles the *T. pallidum* of syphilis that few bacteriologists claim to differentiate them. The disease itself suggests syphilis but is clinically quite distinct from it.

For its production, simple skin contact is not sufficient; a break of surface, previous sore or ulcer is necessary. Probably the virus can be conveyed by insects.

SCURVEY.

Of diseases caused by scant and improper diet among soldiers, scurvy is the only one which needs be considered. It is a disorder characterized by great debility, a spongy condition of the gums and a tendency to hemorrhages. It is produced by the absence of fresh vegetables and fresh meats in the diet, together with the presence of toxic materials generated in the decomposition of certain organic matters.

This disease was formerly very prevalent among soldiers and sailors but, with more varied and wholesome food, it has long ago ceased to play an important part in the morbidity of camps. It is still liable to occur wherever troops are besieged and cut off from fresh supplies; thus, during the Russo-Japanese War, the Russians in Port Arthur suffered severely from it. At the time of the surrender of that fortress there were 9,093 cases of scurvy, out of a total number of 11,105 sick.

CHAPTER VI.

PARASITIC DISEASES.

Of the animal parasites of the circulatory and lymphatic system, *Filaria* is by far the most important one.

Of the several species of this blood-worm, *Filaria bancrofti* (*F. nocturna*) is the most common and widespread. The presence of its tiny larvæ in the blood produces the disease called **filariasis**. They attain their sexual maturity in the lymphatics where fecundation occurs, soon followed by the pouring out of new generations which find their way into the circulation.

This disease, with all its various complications, has a very extensive distribution throughout all tropical and subtropical countries where a large proportion of the poorer natives are often infected with it, and is therefore always a menace to our soldiers in the colonies, several of whom have already suffered from it.

Filariasis is a mosquito-borne disease, being transmitted to man by *Culex fatigans* and probably other insects. Man is the definite host of this blood-worm and the mosquito only the intermediary host (Plate III).

Ashburn and Craig have recently discovered another species (*F. Philippinensis*) in the blood of Filipinos, likewise transmitted by *Culex fatigans*.

The prophylaxis of filariasis is that of all mosquito-borne diseases, namely, destruction of mosquitoes and protection from their bites.

The **Bilharzia** disease is caused by several species of *Schistosomum* (bisexual trematode worm) in the blood and lymph. *S. hæmatobium*, of Africa, lodges mostly in the walls of the bladder, causing chronic hematuria; *S. mansoni*, of the West Indies, inhabits chiefly the mesenteric veins and gives rise to dysenteric symptoms; *S. japonicum*, of Japan and China, is the only species which is not very rare in the Philippine Islands; it attacks specially the liver, spleen and intestines.

Paragonomiasis, not uncommon in the Philippines, is a disease caused by the *Paragonimus westermani*, an oval reddish-brown parasite, half-inch long, inhabiting chiefly the lungs but more rarely also the liver and brain. It is readily diagnosed by a chronic cough, hemoptysis, and the characteristic ova in the rusty-brown sputum.

Opistorchis (*Clonorchis*) *sinensis*, a narrow oblong parasite, 10 to 20 mm. in length, inhabits the bile ducts and gall-bladder. Very common in Japan and China and not rare in the Philippines.

INTESTINAL PARASITES.

In the United States, the most common intestinal parasites, according to Stiles and Garrison (1906), are the following:

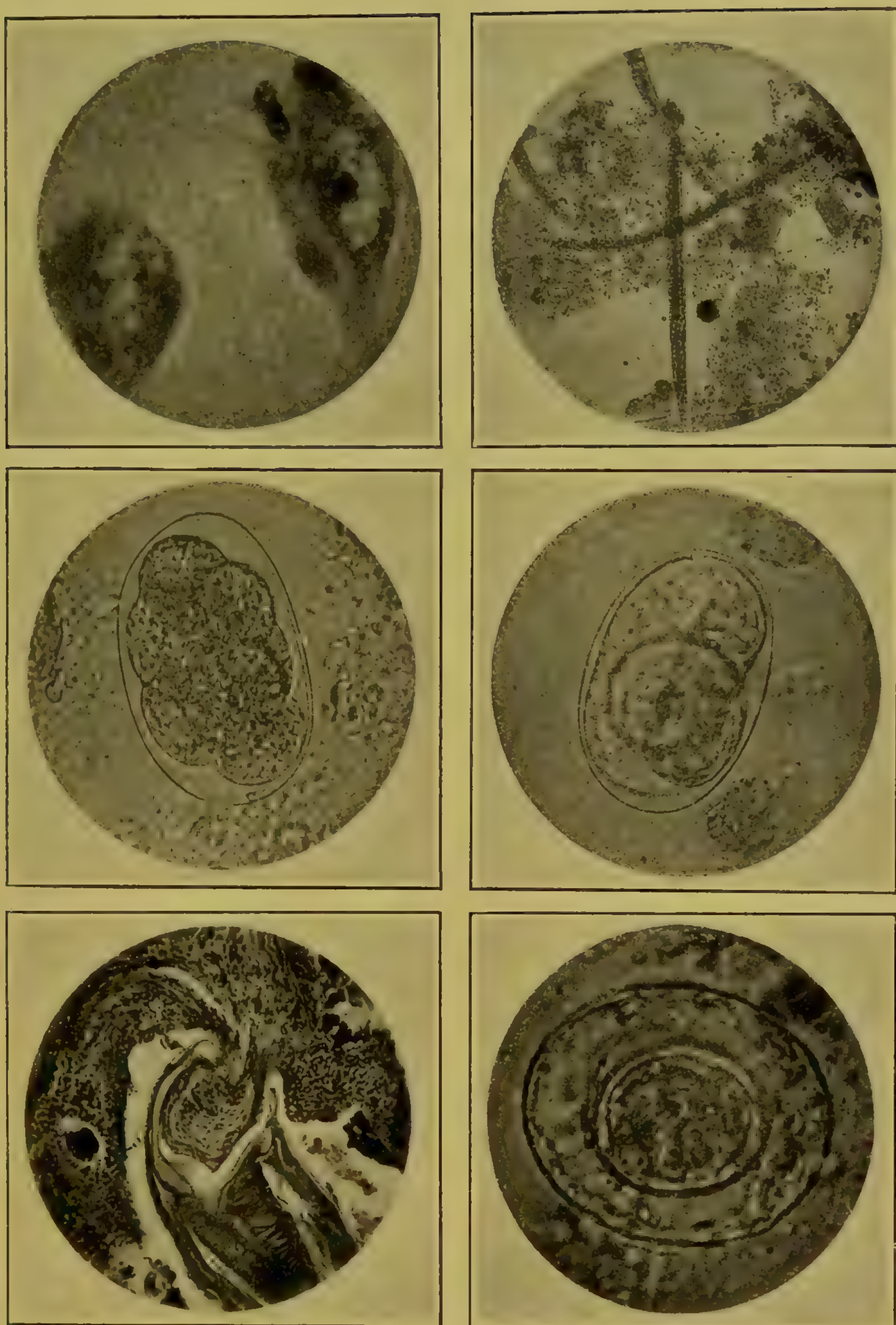
	Per cent. of population in which found.
Trichuris trichiura (*Trichocephalus trichiurus*) Whipworm,	7.69
Oxyuris vermicularis, Pinworm,	1.30
Necator Americanus, New World Hookworm, *Ankylostomum duodenale*, Old World Hookworm,	1.04
Ascaris lumbricoides, Eelworm,	0.49
Hymenolepis nana, Dwarf Tapeworm,	0.35
Strongyloides stercoralis, Cochin-China Worm,	0.23
Tænia saginata, Fat Tapeworm,	0.06

These figures apply mainly to the middle and northern States. In most of the southern States it is well known that the percentage of individuals affected with hookworm far exceeds that of individuals harboring all other parasites combined.

In Porto Rico, the prevalence of intestinal parasites is as follows (1904):

	Per cent. of population.
Necator Americanus,	90 to 100
Ascaris lumbricoides,	31.41
Trichuris trichiura,	7.27
Strongyloides stercoralis,	0.80
Oxyuris vermicularis,	0.07

In the Philippine Islands, not less than 80 per cent. of the population is infected with one or more kinds of intestinal parasites, so that if the different species are separately considered there is an average of about 200 infections to each 100 of population. The most prevalent species are the hookworms which infect 50 to 60 per cent. of the total native population, then Ascaris and Trichuris (Philip E. Garrison). As a remarkable indication of the detrimental effect of intestinal parasites in the tropics, even in the absence of obvious symptoms, may be noted the fact that the mortality of the Bilibid prison (P. I.), in spite of satisfactory sanitary conditions, remained at 75 per 1,000 until the prisoners were systematically treated for parasites, after which the death-rate dropped to about 13 per 1,000 (Garrison).



1. Negri bodies in ganglion cells of brain of dog dead of rabies ($\times$ 1500).
2. Larvæ of *Strongyloides stercoralis* in fresh stool ($\times$ 150).
3. Ovum of *Necator americanus* in fresh stool ($\times$ 1000).
4. Unhatched larva of *Necator americanus* in fresh stool ($\times$ 1000).
5. Adult *Necator americanus* showing head of worm attached to the mucous membrane of the intestine ($\times$ 100).
6. Ovum of *Hymenolepis nana* ($\times$ 1500).

ANKYLOSTOMIASIS.—The hookworms, both Old World and New World species, are not only the most prevalent of intestinal parasites but also the most dangerous, producing a severe form of anemia known as *ankylostomiasis*.

The Old World Hookworm (*Ankylostomum duodenale* or *Uncinaria duodenalis*) is half-inch or less in length, the thread-like body tapering to a narrow neck ending in a mouth cavity armed with 4 hooks and 2 conical teeth. It inhabits the upper part of the small intestine where it attaches itself to the mucous membrane by means of its strong buccal armature, sucking the blood out of it (Plate VII). The female worm produces a prodigious number of eggs which pass out in the feces, thus betraying the presence of the parasite (Plate VII). These ova under the microscope are clear and transparent, with regular oval form and delicate shell through which can easily be seen 4 to 6 grayish yolk segments. They undergo rapid changes and the embryo is born within one or two days. After reaching a certain development, the minute larva, whether in water, mud or sand, remains in a torpid condition waiting for a chance, should it survive, to be transferred to the human alimentary canal where it acquires sexual characters and permanent adult form. Thus it appears that, although the eggs are produced in the intestine, there is no hatching and propagation of the worm in the human body.

The larvæ find their way to the human intestine by two different routes: 1, through drinking water, or from the mud or earth adhering to the hands, food dishes or eating utensils; 2, directly through the skin when coming in contact with it as, for instance, in the case of laborers handling infected soil or walking on it with bare feet (producing "ground itch"). After boring through the skin they enter the blood-vessels and lymphatics and are carried to the lungs, whence they pass to the stomach and intestine.

This parasite occurs nearly in all but the most northern countries, being abundant in the south of Europe as well as in the tropical and subtropical regions of Asia. Also common in America but much less so than the next species.

The New World Hookworm (*Necator Americanus*), differentiated and described by Stiles in 1902, is abundant in the Southern States, Porto Rico, Cuba and very likely in Central America; also a common parasite in the Philippine Islands, and likewise found in certain parts of Africa. In the United States it occurs in a large proportion of the population, white and colored, from New York and Illinois southward and westward to Florida, Louisiana and Texas, especially among the rural farming

classes of sandy zones. It is a shorter and more slender worm than the *Ankylostomum*, the smaller mouth armed with semilunar plates instead of hooks. (Fig. 19.)

Male. Female.

FIG. 19.—Necator Americanus. (*Manson.*)

Often hookworms in the intestine, especially if few in number, give rise to no appreciable symptoms. But if numerous they may, in poorly nourished subjects, especially those already suffering from some chronic exhausting disease, give rise to a severe form of anemia leading to permanent degeneration of important organs and death. The sucking of blood at many points of the mucous membrane produces a constant drain on the system and, through the minute wounds, a greater susceptibility to the attacks of infectious bacteria; it is also believed that additional harm is done by a poisonous substance secreted by the worm. In the Southern Atlantic States, ankylostomiasis must be considered one of the most common and wide spread diseases, especially among the lower classes of whites, being even more prevalent, in rural sand districts, than

tuberculosis and malaria. In Porto Rico, before 1904, from 5,000 to 7,000 natives died from it annually, while 70 per cent. of the worm-carriers were more or less incapacitated in consequence of it (Ashford). It is remarkable that, in the Philippine Islands, severe clinical manifestations of ankylostomiasis are comparatively rare, and that there is no prevalence of anemia among the natives, such as might be attributed to this parasite.

Prophylaxis.—Since the parasite is spread through the stools of patients, fecal contamination of soil and water must be carefully prevented by compelling all people concerned to construct and use privies. Cleanly habits and the wearing of shoes should be insisted upon. The systematic administration of thymol or betanaphthol to all persons affected or suspected, to expel the worm, has produced excellent effects in Porto Rico. Permanent practical results can only be expected after a patient and persistent campaign of education.

CHAPTER VII.

DISEASES CAUSED BY IMMORAL OR INTEMPERATE HABITS.

Venereal Diseases.

These diseases belong to the group of infectious disorders but it is deemed best to consider them by themselves under the above caption.

They include three distinct affections, all infectious and contagious, namely:

1. Gonorrhea, caused by the *gonococcus*, a micro-organism (diplococcus) which not only produces the primary and direct lesions of the genital tract, but may also reach many other parts of the body, resulting in gonorrheal septicemia, endocarditis, arthritis, myositis, ocular complications, neuritis, etc.

2. Soft chancre, caused by the bacillus of Ducrey; this organism is arrested by the inguinal lymph glands, so that the sore always remains localized.

3. Syphilis, caused by a spirally-curved organism or spirochæte (*Treponema pallidum*) which, at first localized in a small, inactive chancre, soon invades the entire system, so that there is no organ in the body nor any tissue in the organs which may not become involved.

Venereal diseases, which always have the highest rate of admissions in peace time, are not nearly so prevalent under the strenuous and exciting conditions of war. During the Civil War and the Spanish-American War they caused fewer admissions (83 and 82 per 1,000 respectively) than several of the other common camp diseases, passing from the first to the fifth place. This, however, was due, not so much to an actual reduction of venereal diseases as to the greatly increased rates of the other diseases.

They are, by far, the most important factor affecting the efficiency of modern armies in peace. Their rates in the United States Army (colonies excluded) are given in the following statement (Report of Surg. Gen., 1907).

	Ratios per 1,000 of mean strength.											
	Admitted.			Discharged on surgeon's certificate of disability.			Died.			Non-effective.		
	White	Colored	Total	White	Colored	Total	White	Colored	Total	White	Colored	Total
Gonorrhea, including other venereal:												
Year 1906......	106.11	91.49	105.21	1.11	0.40	1.07	0.03	....	0.02	6.29	4.48	6.18
Year 1905......	120.12	97.05	118.31	1.25	1.80	1.29	.03	....	.02	6.46	4.08	6.26
Year 1904......	108.60	86.83	107.05	1.10	2.56	1.21	....	....	....	5.79	3.56	5.63
Chancroids:												
Year 1906......	26.01	32.65	26.41	.03	.40	.05	....	....	....	1.69	2.48	1.73
Year 1905......	30.27	31.85	30.39	.05	....	.05	....	....	....	1.88	2.08	1.90
Year 1904......	27.73	30.12	27.90	.07	....	.07	....	....	....	1.74	1.65	1.74
Syphilis:												
Year 1906......	27.34	26.20	27.28	2.90	1.19	2.79	.03	0.40	.05	3.02	2.40	2.98
Year 1905......	30.40	25.54	30.02	3.37	2.70	3.32	....	.30	.02	2.93	2.34	2.88
Year 1904......	29.59	13.78	28.47	3.92	1.60	3.75	.05	....	.05	2.59	.86	2.46
Total venereal:												
Year 1906......	159.47	150.34	158.91	4.03	1.98	3.91	.05	.40	.07	11.00	9.36	10.90
Year 1905......	180.78	154.44	178.72	4.66	4.51	4.66	.03	.30	.04	11.27	8.50	11.05
Year 1904......	165.93	130.73	163.43	5.10	4.17	5.02	.05	....	.05	10.12	6.07	9.83

It is seen that for the 3 years 1904–6, the average annual rates of admissions and non-effectiveness, in the United States, were 167.02 and 10.59 respectively. Bad as are these figures, those for the Philippine Islands are much worse. During the same 3 years, in those Islands, the annual rates of admissions and non-effectiveness were 303.64 and 21.17 respectively.

Taking the whole United States Army, at home and in the colonies, for the same period, the rates of admissions are 193.04; of discharges, 3.39; of non-effective, 12.58. The constantly non-effective, that is the constantly on sick report by reason of venereal diseases, was 710 men, or nearly a full regiment of infantry on peace footing.

The ratio of venereal diseases in the United States Navy appears to be smaller than in the Army, but full statistics are not available. It is stated in the Report of the Surgeon General for 1907, that, in the Navy, this class of diseases is responsible for a larger percentage of sick days, loss of services and invalidism than any other, and that its progressive increase "is alarming and calls for the most serious consideration."

Comparing our rates with those of foreign armies, a great discrepancy is apparent. Thus, for the year 1906, while our rate (troops in United States) was 158.91, that for the United Kingdom was 81.8; for the year 1904, it was 61.6 for Austro-Hungary, 44.7 for Russia, 25 to 30 for France (estimated) and 19.8 for Germany. In trying to account for this

discrepancy it must be remembered that the methods of reporting disease vary in different armies; in some, only patients treated in hospital are accounted for, while in our service all patients excused from any duty, even while in barracks, must be entered on the sick report. As regards venereal diseases, our soldiers, for hygienic reasons, are advised to report to the surgeon as soon as possible, without fear of punishment, and probably fewer fail to do so than in foreign armies.

But after making due allowance for all those causes which render venereal statistics so proverbially unreliable, we must accept the fact that, in this class of diseases, our army occupies an unenviable preeminence. Two general causes will mostly account for this, and they likewise apply *mutatis mutandis* to the preeminence of the British rates among European armies. 1. The American and English soldiers, as volunteers, receive a liberal pay, and financially are much better off than those of other countries under compulsory military service; furthermore, they are not subjected to the same strenuous work and irksome restraints; hence they enjoy greater opportunities and facilities for dissipation. Let the average soldier, from any race or nation, be given money and leisure, and abundant pleasure resorts within easy reach, and the inevitable result, as expressed in terms of venery and alcoholism, can be readily foretold. 2. In continental Europe, the State realizing the gravity of the ravages of venereal infection endeavors to restrain prostitution, or mitigate its effects, by police regulations whereby prostitutes are subjected to systematic registration and examination so that all found diseased may be segregated and cured. There can be no doubt that such a system is justifiable on the part of the State on the ground of self-defense against the most widespread and loathsome of contagious diseases, nor of its great efficacy in checking them, especially among soldiers. But a strong public sentiment has opposed this recognition and regulation of prostitution by the State authorities in England and America, with the result that venereal rates in both countries exceed those of other civilized nations where the system is still more or less in vigor.

Prophylaxis.—Outside of purely moral teaching, with which this Manual is not concerned, the most fruitful prophylactic measure consists in imparting to young soldiers all necessary useful knowledge on the subject, especially a proper appreciation of the gravity of these diseases. Many expose themselves thoughtlessly, with the impression that, at the worst, a few days in hospital will suffice to get rid of the consequences. This is foolish and dangerous ignorance which officers, especially medical officers, should endeavor to dispel by a few plain talks, demonstrating to

them the many complications and sequels of gonorrhea as well as the ravages of syphilis which affect not only the incontinent but, through matrimony, many innocent women and children. Let them be told that, in the opinion of gynecologists, a majority of the hazardous surgical operations performed upon married women are made necessary in consequence of gonorrheal infection by the husband; and another terrifying fact, that syphilis, so far as known, is not only directly transmitted from father to children but the sole disease thus transmitted, as it were a special curse upon the human race.

The life of the soldier in garrison and camp should be made as attractive as possible so that he may not so readily succumb to the allurements of the outside dens which lay their snares for him. The post exchange should have all its recreation features fully developed, such as reading-room, card and billiard rooms, lunch room, gymnasium and bowling-alley. The restoration of the canteen feature, with the regulated sale of beer and other mild spirituous refreshments, would probably do more to keep the men at home and away from the haunts of vice than any other preventive measure.

In this country it is conceded that the control and regulation of prostitution, by special boards of health, is entirely out of the question in ordinary times. But, in war, the conditions are different, and the strong hand of military power can be exerted to protect camps and garrisoned cities from the worst evils of prostitution. It is even reasonable to suppose that, under such circumstances, the civil authorities will willingly lend their coöperation. The registration and inspection of prostitutes, as a measure of military necessity, was done with great success at Nashville and Memphis, Tenn., during the Civil War, so that there are excellent precedents for it.

But if there be any question about the enforced examination of the lewd women plying their trade about posts and camps, there should be none regarding the systematic inspection and treatment of the men themselves. This has been done on various occasions in Cuba and the Philippines, and always with the happiest results. There is no good reason why every enlisted man, sergeants excepted, could not be examined twice a month at the hospital, by a medical officer, and any one found diseased placed under treatment and confined to the limits of the hospital or post. Such inspection need not be restricted to the genital organs; it can readily include the surrounding region or any other part of the body and, at the same time, be made a test of general cleanliness.

It is essential that men contracting venereal diseases, in any form, should submit to treatment as quickly as possible so that the infection

may be attacked when most curable and before complications arise; therefore they must be advised to report to the surgeon as soon as the first symptoms manifest themselves. As part of the treatment, each man should be furnished with a printed leaflet telling him clearly what to do and what to avoid, to cure himself and prevent the infection of comrades.

Alcoholism.

For alcoholism, the annual rate of admissions in the whole Army, at home and abroad, for the 3 years 1904–6, is 29.49 per 1,000; that for discharges, 0.15; for deaths, 0.16, and for non-effective, 0.37. For the period 1898–1904, the rate of admissions was only 22.32 while that for deaths was 0.26; in other words, the cases were fewer but more of them were fatal.

In the United States Navy and Marine Corps, for the years 1905 and 1906, the reported rates of admissions and deaths per 1,000 were 6.94 and 0.12 respectively.

For the year 1906, the rates of admissions and deaths in the United States Army, at home, were 32.07 and 0.02 respectively, while in Great Britain and Ireland they were reported as 1.10 and 0.03. The same mortality with such discrepancy in the number of admissions, shows a radical difference in the methods of accounting for cases. But with all allowances made it must be admitted that, in alcoholic intemperance as in venereal diseases, our army easily stands first.

The reasons already given for the high prevalence of venereal diseases in our army will also explain this high standing in alcoholism. Both forms of vice, alcoholic intemperance and sexual debauchery, are always closely associated, one leading to the other, so that the soldier who frequents the saloon falls an easy prey to the prostitute. It is the conviction of most officers that the abolition of the canteen, that is to say, the prohibition to sell any kind of alcoholic beverage, however mild, on military reservations, has maintained the rates of alcoholism and venereal diseases at an abnormally high level. Most soldiers, at the time they enlist, have formed the habit to indulge moderately, wherever so inclined, in beer or other spirituous refreshment. The fact of becoming soldiers cannot be expected to render them totally abstinent. Formerly they could get beer and other mild beverages at the canteen to any reasonable extent and always under official supervision. This feature of the canteen being abolished, the men now seek their alcoholic refreshments outside, away from supervision and restraint, where, for the weak, there is every inducement to drunkenness. Its restoration has been strongly urged by the War Department and recommended to Congress in Presidential messages.

CHAPTER VIII.

RECRUITING.*

Next to hygiene, the most important factor in securing the physicial efficiency of the soldier is the proper selection of the recruit. None but able-bodied men must be enlisted. They alone can stand the exposure and hardships to which troops are exposed and acquire the endurance to fatigue and resistance to disease which make up the reliable and effective soldier. Delicate, undeveloped and immature young men and those who suffer from chronic ailments are easily exhausted by hard work, privations and the inclemencies of the weather, and an easy prey to infectious diseases, weakening the ranks they are intended to strengthen and falling by the wayside when most needed, so that they crowd the ambulances and hospitals especially needed for the wounded, and later become pensioners of the Government which they never have usefully served. The best hygienic conditions will never make hardy men or good soldiers of them. Not only are they ineffective but, still worse, they often require the care of able-bodied men thus withdrawn from the effective forces.

There is therefore no more important duty devolving upon the medical officer than the examination of applicants for enlistment, none that is productive of better and more important results. This is shown, in our past wars, by the difference between the morbidity and mortality of regulars and those of volunteers, the medical officers of volunteer troops having examined their applicants without the necessary strictness or, rather, having been compelled by the exigencies of the situation to accept, against their better judgment, men below the required standards. Thus, in the Civil War, the annual mortality from disease and discharges for disability were respectively 55 and 91 per 1,000 for volunteers and only 32 and 68 for regulars. In the year 1900, the admissions for disease per 1,000 of strength were 1,821 for regulars and 2,762 for volunteers, while the mortality was 12 and 25 respectively.

This matter of examining applicants for enlistment is deemed so important that, under existing United States Army Regulations, medical officers are required to perform the duties of recruiting officers at recruit

*See Tripler's Manual on the Examination of Recruits, by Chas. R. Greenleaf, Col., Asst. Surg. Gen., U. S. A.

depots and other large posts where they are available for the purpose, and are alone responsible for the acceptance or rejection of applicants.

As a general rule, the higher the social class to which the recruit belongs, the better he will be physically as well as mentally, for it is notorious that in European armies, where military service is obligatory, the officers are usually taller and heavier than the enlisted men. Vision is an exception to this rule, for it grows more imperfect as we ascend the social scale, so that perfect eye-sight is oftener found in the middle and lower than in the higher and better educated classes. The physical and mental aptitudes of recruits are, to a great extent, the resultant of their previous environment, occupation and education; these factors therefore must be duly considered. Youths from the country are stronger, heavier, healthier and more enduring than city-bred boys, generally also of better habits and character, but, on the other hand, they are hard to break in, slow to accommodate themselves to their new conditions and to acquire the smart step and martial bearing of the trained soldier. The city recruit is more supple and adaptable and sooner trained for an emergency, but lacking in vigor, endurance and stability of character.

AGE.—"Applicants for first enlistment must be between the ages of 18 and 35 years, of good character and temperate habits, able-bodied, free from disease, and must be able to speak, read and write the English language.

"No person under 18 years of age will be enlisted, reenlisted, or accepted with a view to enlistment, and minors between the ages of 18 and 21 years must not be enlisted, or accepted with a view to enlistment, without the written consent of the father, only surviving parent, or legally appointed guardian, to the minor's enlistment.

"Original enlistments will be confined to persons who are citizens of the United States or of Porto Rico, or who have made legal declaration of their intention to become citizens of the United States."

It is a well-known fact that the human body grows and develops until at least the age of 25. Before this the bones are not fully formed; the epiphyses are not all ossified and united; the sacrum and sternum are not yet consolidated; nor has the body reached its full height, weight and chest capacity. We enjoy our best physical development and greatest strength from 25 to 30, the lungs not gaining their maximum capacity until 30 or 35. Therefore, in theory, the older the recruit, if under 30, the better he is physically and mentally. But, in practice, there are other aspects of the question to be considered. After 25, most of the desirable young men have chosen their trade or profession, therefore are more or less settled in

life and no longer think of enlisting. Furthermore, at that age their habits are formed and they could not so easily be broken into the new and very different ways of military life. Were it possible to secure enough recruits 22 years old, it would be in the interest of the service to do so; but as this is generally impossible, the minimum age must remain at 21.

In European countries, where the military service is obligatory for all, the age is 20 (21 in Russia), although many of the young conscripts do not really get under the colors until they are 21. There the age has to be that which follows the period of education and precedes that of the selection of a profession or trade.

Experience has shown that, under 20, soldiers are incapable to stand the fatigue and hardships of a campaign, and military history contains many complaints of commanders whose hospitals were full of young, immature soldiers. It is stated that the French army which won the glorious battle of Austerlitz, in 1805, after a forced march of more than 1,000 miles, leaving but few sick en route, contained no men below the age of 22; while the army which won the bloody and indecisive battle of Wagram, in 1809, after scattering many sick and crippled on the way, was mainly composed of young soldiers.

At what age ceases the aptitude for military service? It will seldom be in the interest of the service to enlist men over 30 years old, and the legal limit of 35 is only intended to be used in times of emergency. "It has been observed that for acceptable colored recruits the age of 25 or 26 is practically the maximum, because after that they are liable to be physically stiffened and mentally dulled" (Greenleaf). There is no age limit for re-enlistment in our Army, but it is recognized that the soldier grows old quickly in barracks and in the field. After 20 years in the ranks, when past 40 years of age, he soon becomes unequal to the arduous duties of field service. The Army Regulations provide that when an enlisted man shall have served as such for 30 years he may apply for retirement; but there are few enlisted men who serve usefully and efficiently until the age of 51. The so-called veterans of Napoleon were men of 26 to 28 years, and his "old guard" consisted of men from 28 to 29; at Austerlitz the oldest soldiers were 33, and at Friedland 36 years old (Rouget et Dopter).

Youths under 21 often present the appearance of the physical signs of maturity and may attempt to deceive the recruiting officer. The latter therefore should be very particular to ascertain the correct age of applicants, the more so that a minor who enlists by deceit may, upon application of his parent or guardian, be discharged from the Army, thus causing the loss to the Government not only of his services but of his pay and

equipment. According to Greenleaf, there are certain evidences of maturity which usually accompany the period of legal majority and with which the recruiting officer should familiarize himself.

"At twenty-one years of age the wisdom teeth are usually cut, and on each side of both jaws there should be found five grinders, viz., three large double or molar teeth and two smaller double or bicuspid teeth. In case of the loss of teeth the spaces originally occupied by them may be seen.

"Under twenty-one years of age the wisdom teeth are seldom to be found, and there will, therefore, be but four grinders on each side of both jaws, viz., two molars and two bicuspids.

"At maturity there should be some beard upon the face, and hair under the arms, a full growth around and above the genital organs, and some scattered hairs in the neighborhood of the anus. The hair of the body is generally fine and silky.

"After maturity the hair is thick and coarse in the various places mentioned.

"After maturity the skin of the scrotum is somewhat darker in color than the surrounding parts, is opaque, and is marked in various directions by wrinkles or folds.

"Before maturity this skin retains the soft, velvety condition of youth, its pink or fresh flesh color, and is more or less translucent, while the wrinkles or folds are not well pronounced, or are entirely absent, particularly at the sides. *This condition of the scrotum is the most valuable of the signs of maturity.*"

In hot countries, where man has to contend against depressing climatic conditions and endemic infectious diseases, very young soldiers are particularly exposed to grave dangers and soon become non-effective. Only matured, well-trained men of at least 22 should be sent to the tropics for active duty.

HEIGHT, WEIGHT AND CHEST MEASUREMENT.

To determine the physical condition of applicants for enlistment it is necessary to ascertain that the height, weight and chest measurement come up to established standards and bear certain definite proportions to one another.

Height.—Our Army is recruited not only from native Americans but also from the naturalized emigrants of many countries, differing more or less in physical characteristics. According to Kilbourne, the North American Indians are taller than any other race on this continent, the adult

males averaging 5 feet 7.93 inches. Next in size are the native white Americans, whose average height, in the Civil War, was 5 feet 7.67 inches. Among our naturalized citizens, the Norwegians, Scotch Canadians, Swedes and Irish come next, in the order named. The American negro follows, with an average of 5 feet 6.62 inches. Lowest in the scale, but still above 5 feet 6 inches, are the English, Hungarians, Germans, Swiss, French and Poles. The Italians and Austrians are 5 feet 6 inches or under.

In this country, "the average stature of a youth of 18 years of age, a 'growing lad,' is a little over 5 feet 4 inches, and this increases gradually until he reaches the age of 25 years—about the stage of physical maturity or manhood—when his average height is between 5 feet 7 inches and 5 feet 8 inches" (Greenleaf).

Our Army Regulations provide that: For infantry, coast artillery and engineers the height must not be less than 5 feet 4 inches; for cavalry and field artillery (except mountain batteries), not less than 5 feet 4 inches and not more than 5 feet 10 inches; for mountain batteries, not less than 5 feet 8 inches and not more than 6 feet. A variation not exceeding a fraction of an inch above the maximum height given for cavalry and artillery, is permissible if the applicant is in good health and in other respects desirable as a recruit.

In foreign countries, the minimum height is 64 inches for the English, 62 for the Germans and less than 62 for other armies. In the French army, the minimum limit, reduced to 60.5 inches in 1872, was entirely discarded in 1901, on the ground (for us inadmissible) that physical aptitude is independent of height.

In a full-grown and well-proportioned subject, his strength and staying power increase with his height, but a maximum limit is soon reached beyond which it is not advisable to go. Tall men, that is, men exceeding 6 feet, are objectionable, for in them, as a rule, the lungs and heart are not developed nor their muscular energy increased in proportion to their height, so that they are less able to stand hard marching and endure hardships than much smaller men. The wonderful marching ability of the small French soldier is well known. Furthermore, tall men require more food, more clothing, and—not a negligible consideration—offer a larger target to the enemy.

For admission to the United States Military Academy, candidates 17 years old must be at least 64 inches tall, and those 18 years and upward at least 65 inches.

Weight.—In our Army the minimum weight for all arms of the service is

128 pounds, subject to slight variations as explained on p. 80; but in no case will an applicant whose weight falls below 120 pounds be accepted without special authority from the Adjutant General of the Army. The maximum must not exceed 190 pounds for infantry, coast artillery and engineers, nor 165 pounds for cavalry and field artillery.

Weight is of the greatest importance in the examination of recruits, giving, in connection with the height, a valuable indication of the development of organs as well as of the firmness and compactness of tissues, but it is necessary to see that the weight is chiefly that of the organs and tissues most concerned in the production of physical strength, namely, bones and muscles, and that there is no excess of fat or protuberance of abdomen.

In our service, the proportion which should exist between height and weight is formulated by Greenleaf as follows:

"For each inch of height from 5 feet 4 inches to 5 feet 7 inches, inclusive, there should be calculated 2 pounds of weight. When the height *exceeds* 5 feet 7 inches, calculate 2 pounds of weight for the *whole number* of inches of height; add to this product 5 pounds of weight for each inch of difference between 5 feet 7 inches and the actual height; the sum will be the normal weight in pounds."

In Europe, the minimum weight admissible ranges from 110 to 120 pounds. The weight requirement, in proportion to size, is also somewhat less than with us; thus in France and Belgium, the recruit is accepted if his weight is 7 or 8 kilos below the number represented by the decimals of his height expressed in the metric system; for instance, a man 1 meter 63 centimeters high (64 inches) need not weigh more than $63 - 7 = 56$ kilos, or 123 pounds.

Chest Measurement.—The chest contains the heart and lungs, the most important organs of the body; therefore its development is of particular significance as indicating the vital power and endurance of the recruit. As the body increases in size and weight, a proportional increase of the chest must take place in order to furnish the greater amount of nervous and muscular energy required. A short, narrow or thin chest is never desirable in an applicant for enlistment, particularly if long-legged.

A still more useful indication than the mere size of the thorax is the respiratory capacity of the lungs. This capacity is best determined by the spirometer which shows the actual amount of expired air after a forced inspiration. But the use of this apparatus has not been found practical and reliable so that, in all armies, the respiratory capacity is simply determined by measuring the chest mobility.

According to the regulations governing recruiting in our Army, "The chest mobility, *i. e.*, the difference between the measurement at inspiration and expiration, should be at least 2 inches in men below 5 feet 7 inches in height, and 2 1/2 inches in those above that height." A large proportion of men have a chest expansion of 3 to 4 inches.

It may be formulated, in a general way, that the measurement at expiration should be at least equal to one-half of the height; thus a man 66 inches high should not measure less than 33 inches. In our service, the rule is that a man whose chest measures less than 32 inches at expiration, whatever his height may be, should be rejected, unless otherwise specially desirable.

Antony found that in French soldiers affected with respiratory diseases, especially tuberculosis, 43 per cent. present a chest perimeter smaller than half the height.

"The circumference of the chest is measured by passing the tape around it immediately at the point of the shoulder blade, the arms hanging down. Generally the tape will then be found to fall below the nipple.

"In taking this measure contortions of the body, such as bending backward to "throw out" the chest or bending forward to "draw it in," should be avoided.

"The applicant should stand erect without muscular strain or rigidity. After the tape is placed in position and lies snugly and evenly upon the skin and while the loose ends are held between the fingers of the examiner so that when the chest is expanded the tape will run readily through them, the applicant should be directed to *draw in slowly and steadily a long breath* until his chest is inflated to its utmost capacity, when the record of *chest circumference at inspiration* should be read from the tape. He is then to expel the air by counting slowly and steadily from one onward until he can no longer resist the urgent demand for inspiration, when the record of *chest circumference at expiration* should be read. This should be repeated several times to insure accuracy. Many men are extremely awkward in developing their chest capacity on demand and great care and patience are necessary in getting the true measurements" (Greenleaf).

The French regulations prescribe to place the tape along the lower pectoral line, which is 2 or 3 centimeters below the nipple.

The following table is given in our recruiting regulations for convenience of reference:

Table of physical proportions for height, weight, and chest measurement.

Height	Weight	Chest measurement	
		At expiration	Mobility
Inches	*Pounds*	*Inches*	*Inches*
64	128	32	[illegible]
65	130	32	2
66	132	32½	2
67	134	33	2
68	141	33¼	2½
69	148	33½	2½
70	155	34	2½
71	162	34¼	2½
72	169	34¾	3
73	176	35¼	3

It is not necessary that the applicant should conform exactly to the figures indicated in the foregoing table. The following variations below the standard given in the table are permissible when the applicant for enlistment is *active, has firm muscles, and is evidently vigorous and healthy:*

Height	Chest at expiration	Weight
Inches	*Inches*	*Pounds*
64 and under 68	2	8
68 and under 69	2	12
69 and under 70	2	15
70 and upward	2	20

In 1897, there were 6,062 native whites accepted for the United States service. Of these, 3,243 ranged in age from 21 to 24; they averaged in height 67.79 inches, and in chest measurement 33.92 inches at expiration and 36.99 inches at inspiration. The remaining 2,819 ranged in age from 25 to 39, with practically the same average height but about a half-inch increase of chest measurement, at both expiration and inspiration, the expansion being the same, almost exactly 3 inches.

During the Civil War, Baxter found that the native-born whites had an average expansion of 2.80 inches.

MODE OF EXAMINING AN APPLICANT FOR ENLISTMENT.

This examination is physical, mental and moral.

Physical.—The recruit is to be examined stripped, in a large, well-lighted room, after he has taken a bath. The examining officer proceeds in the following order:

1. General physique, skin, scalp and cranium, ears, eyes, nose, mouth, face, neck and chest; chest measurements.

2. The arms being extended above the head, backs of hands together, the applicant is required to cough vigorously; any form of rupture may now be discovered by the hand and eye, but still better by the index finger passed up to the external ring.

3. The arms remaining extended above the head, the man is required to take a long step forward with the right foot and bend the right knee; the genital organs are now conveniently exposed and varicocele and other defects in the scrotum may be recognized.

4. Arms down and the man required to separate the buttocks with his hands, at the same time bending forward; this exposes the anus.

5. Heart and lungs; rate of pulse and respiration.

6. Upper extremities, making sure that all joints are free and supple, from the phalanges to the shoulder.

7. Lower extremities; the applicant is required to leap directly up, striking the buttocks with the heels, to hop the length of the room on the ball of first one foot and then the other, to make a standing jump as far as possible and repeat it several times, to run the length of the room in double-time several times; after which his heart and lungs are reexamined.

Mental and Moral.—No standard is prescribed for the mental examination but the man should be able to read and write, and give evidence of primary education and of normal, sound understanding. The advances in the art of war and the use of modern weapons require a much higher degree of intelligence on the part of recruits than formerly, and no future war can be waged successfully except by soldiers who think for themselves and have a clear conception of their duties.

The moral character should be scrutinized with care in order that enlistments from the vagrant, vicious and criminal classes may be avoided. The evils of intemperance in the use of stimulants or narcotics are so great that men whose habits in this respect are under suspicion should be rigidly excluded. It may sometimes be difficult to form a correct opinion of the character of the applicant, but "long indulgence in habits of in-

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temperance will almost surely be indicated by persistent redness of the eyes, tremulousness of the hands, attenuation of the muscles—particularly of the lower extremities—sluggishness of the intellect, an eruption upon the face and purple blotches upon the legs." In the drunkard, the face and nose are often congested, with dilatation of superficial capillaries, producing a bloated appearance; there may be a prominent dropsical abdomen; the pulse is soft and quick and the skin hot.

VISION AND HEARING.

Vision.—To determine the acuity of vision, place the applicant with back to the window at a distance of 20 feet from the test types. Examine each eye separately, covering the other eye with a card (not with the hand). The applicant is directed to read the test types from the top of the chart down as far as he can see, and his acuity of vision recorded for each eye, with the distance of 20 feet as the numerator of a fraction and the size of the type of the lowest line he can read correctly as the denominator. If he reads the 20-feet type correctly his vision is normal and recorded 20/20; if he does not read below the 30-feet type, the vision is imperfect and recorded 20/30; if he reads the 15-feet type, the vision is unusually acute and recorded 20/15, etc

Until very recently, normal vision was required of all recruits, with few exceptions, but the experiments of Banister and Shaw, Med. Corps, United States Army, have shown conclusively:

That a perfectly sharp image of the target or bull's-eye is not necessary for good shooting.

That a visual acuity of 20/40, or even 20/70, in the aiming eye is consistent with good shooting, provided the soldier is able to accurately focus both sights of his rifle.

That as rifle shooting is an act of monocular vision, a comparatively high standard of vision is necessary for one eye only.

In accordance with these conclusions, the prescribed minimum visual requirements in the United States Army are now as follows:

"1. For the line of the Army and for the Signal Corps: 20/40 for the better eye, and 20/100 for the poorer eye, provided that no organic disease exists in either eye.

"Recruits may be accepted for the line of the Army when unable with the better eye to correctly read all of the letters on the 20/40 line, provided they are able to read some of the letters on the 20/30 line.

"2. For the Ordnance Department and for the Hospital Corps: 20/70

in each eye, correctible to 20/40 with glasses, provided that no organic disease exists in either eye."

In the examination of candidates for admission to the United States Military Academy and of candidates for commission whether from the ranks or from civil life, the vision, as determined by the official test types, must not fall below 20/40 in either eye, and not below 20/20 unless the defect is a simple refractive error, not hyperopia, is not due to ocular disease, and is entirely corrected by proper glasses. Hyperopia requiring any spherical correction, anisometropia, squint or muscular insufficiency, if marked, are causes for rejection.

For admission to the United States Military Academy, as well as for candidates for commission, color blindness, red, green, or violet, is cause for rejection. For enlistment it is only a bar for applicants for the Signal Corps.

Hearing.—To determine the acuity of hearing, place the applicant facing away from an assistant who is 20 feet distant, and direct him to repeat promptly the words spoken by the assistant. If he cannot hear the words at 20 feet, the assistant should approach foot by foot, using the same voice, until the words are repeated correctly. Examine each ear separately, closing the other ear with the thumb or finger-tip placed well into it. The examiner, whose hearing should be normal, faces in the same direction as the candidate and closes one of his own ears in the same way as a control. The assistant should use a low conversational voice (not a whisper), just plainly audible to the examiner, and should use figures, names of places, or other words or sentences until the condition of the applicant's hearing is evident. The acuity of hearing is expressed in a fraction, the numerator of which is the distance at which the words are heard by the candidate, and the denominator the distance, in feet, at which the words are heard by the normal ear; thus 20/20 records normal hearing, 10/20 imperfect hearing, etc.

Deafness of either ear constitutes an absolute cause of rejection. A slight degree of deafness in only one ear may be overlooked.

SPECIAL DISQUALIFICATIONS.

The following defects and conditions are the most frequent causes of rejection:

Skin.—Chronic, contagious and parasitic diseases, vermin, chronic ulcers.

Head.—Abrupt depression in skull, the consequence of old fracture; marked baldness.

Spine.—Curvatures, caries, abscess. Lateral curvature is cause for rejection when it exceeds one inch to either side of the line of spinous processes, especially when it throws the shoulders out of symmetry.

Ears.—Deafness of one or both ears; all catarrhal and purulent forms of otitis media; perforation of tympanum.

Eyes.—Defective vision in either eye; conjunctival affections, including trachoma and entropion; strabismus, diseases of the lachrymal apparatus, exophthalmos, ptosis, asthenopia, nystagmus.

Mouth and Fauces.—Deformities interfering with mastication or speech, chronic ulcerations, fissures or perforations of the hard palate, hypertrophy of the tonsils sufficient to interfere with respiration or phonation, loss of voice or manifest alteration of it. The applicant must have "at least six serviceable molar teeth, two above and two below on one side and one above and one below on the other side, and so opposed as to serve the purpose of mastication."

Neck.—Goiter, great enlargement or ulcerations of the cervical glands.

Chest.—Diseases of lungs and heart, especially in flat or narrow or malformed chest. In examining the heart, care must be taken not to ascribe to disease the hurried, sharply accentuated action sometimes due to nervousness, fright or embarrassment, or the irregular action caused by the excessive use of tobacco. Nor should the examiner attach undue importance to the soft systolic murmurs often heard in growing athletic youths, functional and temporary in their nature.

Abdomen.—Chronic inflammations of the gastro-intestinal tract, including diarrhea and dysentery, and other diseases of contained organs; hernia in all situations.

Anus.—Hemorrhoids, prolapsus, fistula and fissures.

Genito-urinary organs.—Syphilis in all its stages; venereal sores (both chancre and chancroid) and gonorrhea whether acute or chronic; urethral stricture, balanitis, phimosis, undescended testicle, orchitis, hydrocele, incontinence of urine; all diseases of the bladder and kidneys. Varicocele "does not constitute a cause of rejection unless it is either painful or so large as to interfere with locomotion"; it frequently occurs among the most robust men and often without their being aware of its existence.

Affections common to both extremities.—Chronic rheumatism, diseases of joints, irreducible dislocations or false joints, old dislocations if attended with impairment of motion or distortion of the joint, severe sprains, synovitis, badly united fractures, caries, necrosis, atrophy or paralysis, extensive or adherent scars, permanent contraction of muscles.

Hands.—Webbed finger, permanent flexion, extension or loss of motion

of one or more fingers; loss or serious mutilation of either thumb, total loss of index finger of the right hand, total loss of any two fingers of the same hand, or loss of the second and third phalanges of all the fingers of either hand.

Lower Extremities.—Varicose veins, especially when attended with edema or marks of ulceration, knock-knees, club feet, flat feet, webbed toes, bunions, overriding or marked displacement or deformity of any of the toes, hammer toes, ingrowing nail, corns on the soles of the feet.

CHAPTER IX.

EXERCISE.

"*We march with our muscles, run with our lungs, gallop with our heart, resist with our stomach and succeed with our brain.*" (Dr. Phillippe Tissié).

Exercise should not be regarded merely as an amusement or recreation but also as an obligation, inasmuch as it is indispensable for the maintenance of body and mind in a healthy condition and the proper performance of all bodily functions. Correctly applied, it not only maintains health but corrects physical defects, supplies deficiencies by strengthening and developing our organs and rendering them capable of greater and more persistent effort. It is therefore especially needed by the recruit in order to train him into a strong, agile and enduring soldier and obtain from him a maximum of useful work.

PHYSIOLOGY OF EXERCISE.

A few general remarks on the physiology of exercise may clear the way and lead to a better comprehension of the subject.

We know that our nervous energy and consequent capacity for mental and physical work depend upon active cell metabolism, that is, constant and rapid renovation of tissues. The most vital factor in this work of nutrition, assimilation, dissimilation and elimination, whereby heat and energy are evolved, is oxygen. Unless the blood be thoroughly oxygenated, all functions suffer. An abundant supply of oxygen to the tissues is the great end of exercise.

When voluntary muscles are set in motion, they require more blood, especially more oxygen. If this motion be active and continued, or becomes violent, the need of oxygen is so much greater that the heart is stimulated to quicker action in order to furnish a more rapid flow of blood to the contracting fibers; hence the increased frequency of pulse in exercise. But since the blood obtains its oxygen from the lungs, it follows that, simultaneously with increased pulse there must be increased respiration, increased first in depth and then also in frequency. Heart and lungs, then, are functionally, as well as structurally, very intimately connected, and any stimulation or disturbance of the one is necessarily felt by the other.

At the beginning of active exercise more venous blood is returned to the heart; the right ventricle labors to empty this increased amount into the resistant lungs. There is, in this first stage, a rise of blood pressure, indicated by the labored heart-beats and more or less breathlessness. But soon the resistance lessens; the lungs expand, the peripheral vessels dilate and the blood pressure falls; the heart pulls itself together and the so-called "second wind" is established.

The greater the amount of oxygen absorbed, the greater is the amount of carbonic acid produced, the greater is its accumulation in the blood and the more rapid its exhalation from the lungs. At first, the greater respiratory energy, the deeper and quicker breath, will cause an adequate elimination of this obnoxious gas, but as the exercise continues or increases in violence the equilibrium is destroyed between its production and the eliminating power of the lungs; it accumulates in the system and respiratory distress occurs. This accumulation is doubtless the chief cause of the dyspnea or breathlessness of violent exercise, a much more important factor in its production than cardiac disturbance; thus, when, from strenuous muscular effort, the pulse and respiration have doubled in frequency, it will be noticed that, after a rest of a few minutes, when the dyspnea is all over and respiration has returned to its ordinary rhythm, the pulse rate continues much above the normal; whence we may conclude that, since the heart does not recover its normal action until long after the disappearance of dyspnea, it cannot be the main agent in its production.

The gentle or moderate exercise of a few muscles, for instance, those of the upper extremity, may not produce any appreciable fatigue, or, if prolonged, may produce only local fatigue without respiratory difficulty; but in all violent muscular effort there is always a corresponding disturbance of heart and lungs, a disturbance which is in direct ratio to the sum total of work done, and therefore not necessarily proportional to the degree of fatigue felt; thus, as mentioned above, a man may be tired with hardly any increase of pulse or breathing, while, on the other hand, he may run up-stairs and get out of breath without muscular fatigue.

It is readily understood that, whenever the heart is spurred on to more vigorous effort, not only the working muscles are benefited but, through the greater velocity of the more highly oxygenated blood, all the organs and tissues of the body receive an increased share of oxygen and other nutritive principles; therefore the man who walks not only exercises his lower extremities but his brain and liver as well.

The brain which thinks is analogous to the muscle that contracts; more

blood flows through it, producing more active combustion, greater heat and increased dissimilation. Thinking, then, is exercise for the brain, but an incomplete one, for the waste products accumulate faster than they are eliminated and a clogging of the mental machinery is liable to occur. In order to get rid of them and increase the supply of nutritive principles, we need a quicker blood current, that is to say, the increased action of the heart and lungs produced by muscular exercise. Hence, it follows that gymnastics and athletics are necessary for the brain. It follows also that when, from violent or continued physical work, the system becomes saturated with carbonic acid and other waste products, and fatigue more or less intense results, the brain is affected as much as the muscles and unable to function properly. It is a great mistake to imagine that the brain does not share the fatigue of the body and that a physically exhausted man can think as clearly and successfully as when in a state of rest.

Exercises have been divided into exercises of strength, exercises of speed and exercises of endurance. We might add a fourth category, namely, exercises of skill. In all games and sports the characteristics of these several classes of exercises are more or less combined.

Exercises of strength, such as wrestling, lifting weights, tug of war, etc., demand the simultaneous, sustained action and whole force of many muscles. In order that these muscles may take a very firm attachment, it is necessary that the chest be filled with air and all the bones of the trunk strongly fixed, with glottis closed. This fixation of the trunk requires will-power, a special effort. Exercises of strength cause an abundant and continuous flow of blood into the muscles and produce all the conditions necessary for energetic tissue repair. They need very little work of co-ordination, or repetition of movement, occasion but little nervous disturbance and do not demand great brain work; in other words, "they increase energetically, and even violently, the working of all the organs of the body, while leaving in relative repose the nerve centers and psychical faculties."*

Exercises of speed are those which require frequent repetition of movement; the muscles are not called on to act with their utmost energy, but to contract and relax a great many times and at very short intervals, the result being the same amount of mechanical work performed and the same increased activity of the respiratory and cardiac functions as in exercises of strength; but experiments have shown that muscles subjected to small, frequently repeated contractions, receive less blood than during one

*Physiology of Bodily Exercises. Lagrange.

long-sustained contraction; therefore the nutrition and development of muscles is much less marked in exercises of speed than in exercises of strength; it is noted that professional runners have trim legs and comparatively small calves. Furthermore, Lagrange also calls attention to the excessive expenditure of nervous energy and certain phenomena of exhaustion produced by exercises of speed, out of proportion to the quantity of mechanical work performed; a state of nervous excitability which prevents repose and sleep defective nutrition and repair, and, sometimes, great loss of weight.

Exercises of endurance are those in which the muscular effort is moderate and the movements not too rapid, but in which the work is continued for a long time. The duration is subordinate to the power of the lungs and heart, and the intensity of the nervous energy which actuates them. Walking is the type of exercises of endurance, but when performed up a steep slope may become an exercise of strength. Rowing over a short course is mostly a work of speed, but, in a long race, becomes a work of endurance. In these exercises all the functions are stimulated but in a milder way and without danger of violence to any organ. A serious objection is that they do not excite the respiratory movements with sufficient strength to expand the air-cells and increase the capacity of the chest. They are also rather tedious and irksome from the monotony of the same movements long continued. For these reasons they are best adapted to the physically weak or defective as well as to persons of ripe age.

In exercises of skill, the psychical faculties are more severely taxed than in any other kind; they require speed, repetition and accuracy of movement, and special training of certain sets of muscles. Their effects are mainly those of exercises of speed, but as moments of rest are more frequent and the strain is less continuous, they seldom give rise to the utter prostration which occurs, for instance, in running and rowing races.

EFFECT OF EXERCISE ON MUSCLES.

The voluntary muscles make up the bulk of the body. They consist of fibers which, through the nerves, contract and relax in obedience to the will, thus acting upon the bones and producing the various movements of the body. Exercise, that is, the frequent contraction and extension of the muscle, especially against resistance, at first produces (especially in fleshy and stout men) a reduction in the size of it, as well as in the total weight of the body, due to the melting away of all superfluous fat; but after two or three weeks, the muscles begin to increase in size, hardness,

power and endurance. The increase in size is due to the more active growth of the individual fibers and not to any multiplication of their number. Systematic exercise also develops a quicker command and more perfect control of all our muscles so that complex movements and delicate manipulations requiring the simultaneous play of many muscles become easier and less fatiguing. Hence the alertness of the trained soldier, that is, his power to respond quickly to the perceptions of the senses and execute promptly the commands of his officers.

Involuntary muscles are also strongly affected by exercise, their health and the activity of their physiological rocesses depending greatly upon the work of the voluntary muscles.

EFFECT OF EXERCISE ON THE HEART.

As stated before, the heart is concerned in any form of exercise. More blood has to be sent to the working muscles and the heart must supply it by increased contractions, so that its fibers, like those of other muscles, undergo a more rapid oxidation and renovation. The result is increase in size and power, as well as in frequency of beat. The ventricular walls become thicker and stronger, especially on the left side, and the whole organ enlarged or hypertrophied. This hypertrophy is a normal physiological process and must be one of the most important aims of exercise, for physical power necessarily depends upon strength of heart.

Another ordinary and normal effect of strenuous athletics is temporary dilatation of the right side of the heart, due to the passive congestion of the lungs and increased intracardiac pressure existing in the primary stage of muscular effort. To this dilatation are chiefly due the increased size of the heart during and immediately after a hard contested game, and various murmurs often heard at that time over the cardiac region.

The accommodating power of the heart is enormous, and so long as the strain upon it is not excessive and prolonged, it recovers itself without ill effect. Thus the pulse may rise to 160, 175, even to 200, without permanent injury, provided the heart be given time to recuperate. But, unless the training has been carefully graded and the muscular effort is always kept within physiological limits, there is constant risk, in violent exercise, of incurring the dangers of overstrain.

In young healthy soldiers and students, even when not engaged in active athletics, functional and temporary murmurs over the precordial region are common and their significance must not be exaggerated. They are often the result of training, worry and excitement, and disappear as the subject grows stronger or returns to quieter conditions.

These murmurs are almost always systolic (with first sound or immediately after), soft, blowing in character and heard with greater frequency at the base of the heart, although likewise common at the apex. Perhaps the greatest number are heard over the pulmonary area, in the second left interspace, close to the sternum. They have been ascribed to dilatation of the pulmonary artery (conus arteriosus), and to leakage of the mitral and aortic orifices due to temporary dilatation of the heart and unequal tension of the valve leaflets. Unless these murmurs are accompanied by cardiac enlargement, venous engorgement, dyspnea or disease of some other organ, they cannot be regarded as indicative of organic heart disease.

EFFECT OF EXERCISE ON THE LUNGS.

The end of exercise being a large supply of oxygen to the tissues, it follows that the organs which supply this oxygen must be adequately developed and equal to the demands made upon them. Therefore it is impossible to expect stout arms, vigorous legs and strong heart except with an ample chest capable of large expansion. During exercise there is a largely increased absorption of oxygen and a correspondingly larger production and elimination of carbon dioxid, aqueous vapor and other waste matters; therefore the respiratory function is greatly stimulated. Thus a man marching fast will inhale five times as much air as if reclining, at rest. This means that instead of breathing 18 times a minute and inhaling 25 cubic inches of air at each inhalation, or a total of 450 inches a minute, he will breathe so much more frequently and deeply as to inhale 2,250 cubic inches. The amount of oxygen absorbed during an average working day is about one third greater than during a day of inaction. During severe labor, the consumption of oxygen and excretion of carbon dioxid and aqueous vapor are frequently increased from 7 to 10 times. Nothing therefore should interfere with the free play of the lungs during work or exercise, neither tight clothing nor badly suspended or ill-distributed equipment.

It is very important that, in all exercises, so far as possible, the breathing be through the nose, in order that the inhaled air be warmed up by the expanded and convoluted surfaces of the nasal passages to nearly the temperature of the body, before entering the lungs. But in severe exercise, as in games and races, it is impossible to inhale enough air through the nose, and the mouth must be kept open. Under such conditions, mouth-breathing can be done with impunity or even with advantage, for the

body temperature is then more or less above normal, and colder air taken into the lungs tends to cool the body and restore the equilibrium.

Few soldiers know how to expand their chests properly so as to fill up all the air vesicles and take the fullest advantage of their respiratory capacity. They must be taught the proper use of all the respiratory muscles, including the diaphragm. The usual tendency is to expand chiefly the upper part of the lungs, raising the clavicles and shoulders, but complete respiration must be abdominal as well as thoracic. While the ribs and sternum are drawn outward, the diaphragm should be correspondingly depressed, so that the lower lobe be as fully expanded as the upper lobe. The shoulders must not be perceptibly raised. The Drill Regulations prescribe that the lungs should be inflated to full capacity by short successive inhalations through the nose, and emptied by a continuous exhalation through the mouth. The rhythm should be as nearly normal as possible, that is, the inspiration followed without delay by the expiration; holding the breath with a fully expanded chest is harmful to heart, lungs and abdominal muscles and should be avoided.

Under proper military training an increase of chest measurement and mobility are soon noticed. The average increase in size, at the end of the first year, is about an inch (Abel, Chassagne and Dally) and that in mobility, according to Fetzer, very little less (21 mm.). The vital capacity, in the experiments of Fetzer, rose from 3 lit. 800 to 4 lit. 500; Dettling has seen it reach 5 and even 6 liters, at the school of Joinville.

The classes which graduated at the United States Military Academy in 1900, 1901, 1903, 1904 (346 cadets in all), gave a measurement of 35.48 inches at expiration and 37.78 inches at inspiration, with mobility of 2.30 inches. At the time of entrance, four years before, the measurements had been 33.72 and 35.90 respectively, with 2.18 mobility. Therefore the increase during their stay at the Academy, as the result of natural growth, drill, gymnastics and athletics, was 1.76 inches at expiration and 1.88 at inspiration, the mobility meanwhile having only increased 0.12.

It has also been observed that the effect of exercise is to reduce the number of respirations and increase their depth. Thus Marey has seen the number fall from 20 to 12 a minute while the amplitude was almost quadrupled.

EFFECT OF EXERCISE ON THE SKIN.

Exercise causes an increased supply of blood to the surface of the body, dilating the peripheral capillaries and reddening the skin; at the same time the sweat glands are stimulated and pour out an abundant excretion.

From the more active oxidation and combustion of the tissues produced by exertion, the body temperature is increased, and this increase would soon cause serious injury to the system were not means provided to check it. These are the direct radiation of heat from the congested skin and the evaporation of the sweat, so that an equilibrium is maintained and the body temperature seldom rises more than 1° F. above normal. As sweat continues to be excreted and evaporated after the exercise ceases, the temperature soon falls to normal, or even below, and a chilly sensation results if the skin is not properly protected; hence the need of a sweater or woolen garment after active work. Under the effect of strenuous and sustained exertion, during a game or race, it is not unusual to see the temperature fall one degree or even more below normal, without subsequent ill effects, provided the young athlete is at once wrapped up in a blanket and allowed to recuperate.

EFFECT OF EXERCISE ON HEIGHT AND WEIGHT.

Height is sensibly increased by exercise in young men under 20, especially under 18, but it is doubtful whether that of young soldiers (21 years old or over) is perceptibly affected.

The average increase of height of the four classes which graduated at the United States Military Academy in 1900, 1901, 1903 and 1904, during the four or more years of their stay at the Academy, was 0.97 inch (from 67.85 inches to 68.82 inches). Their average age at entrance was slightly over 19. An investigation of the height of many young officers, several years after leaving the Academy, shows that there is no increase after 23 years of age.

Weight is quickly and markedly affected by exercise. In the first stage there is almost always a temporary loss ranging from a few ounces to a few pounds, but this is readily made up in a few days by a more active digestion and greater absorption of food. This loss is due not only to the oxidation of fat and glycogen (or its product, alcohol) but also to an increase of all the excretions, especially sweat; it may continue or increase if violent exercise is persisted in, without sufficient recuperation, and then becomes one of the signs of overtraining. The permanent gain in weight, the net result of exercise, varies according to the physical condition of the subject, being much greater in small and immature than in large, well-developed men. This probably explains the striking results obtained in the training of recruits in certain European countries, as compared with our own results. Dettling found that after three months' training at the gymnasium, the young soldiers of the Joinville School had gained 2.425

kilos, or 5.33 pounds. Similar figures are recorded by other German and French military gymnastic schools. According to Onslow, the average increase in British soldiers who completed the full course of training, in 1887, was 2 1/2 pounds. In this country, Butts determined that after a course of instruction at Columbus Barracks extending over a period of 3 1/2 months, the average gain was 2.81 pounds. At Harvard, the increase of weight, based upon a class of 200 men averaging 18.3 years, after 6 months of moderate work in the gymnasium, was 2 pounds.

The total average increase in weight of the four classes which graduated at the United States Military Academy in 1900, 1901, 1903 and 1904, as the result of natural growth, drill, gymnastics and athletics during the four or more years of their stay at the Academy, was 5.62 pounds (from 141.16 to 146.78 pounds).

The increase in weight produced by exercise is almost exclusively in the muscles which, in consequence, become harder and larger, so that there is a gain in the size of all parts of the body, including chest, shoulders, hips, upper and lower extremities. The only exception is in the waist and abdomen which become reduced in size, much of the fat stored in these situations being oxidized. Thus Butts found that the average loss in the waist of recruits was about one inch.

REGULATION OF EXERCISE.

Young soldiers not accustomed to systematic training have but little endurance and are soon tired out. Therefore the exercises should be easy and short at first, gradually increasing in duration and intensity, but ceasing as soon as great fatigue is noticed. As the training of the recruit progresses, his muscles become stronger and his joints more supple, his movements are better coordinated, almost automatic; he feels fatigue less and less and becomes capable of strenuous and long-sustained efforts without losing breath and without exhaustion. It is only when thus perfectly trained that he is equal to the physical demands which are made upon him in camps of maneuvers, in the field, on the march or on the battlefield.

The rules which should guide instructors in drilling recruits may be formulated as follows:

1. The exercises should be progressive, each day a little harder than the previous day, but without fatigue, avoiding violent, sudden efforts for which the recruit is not yet prepared.

2. Each man should be examined with a view to his special needs and

deficiencies, and placed in the section or squad where he may receive the training most appropriate to his condition.

3. Agility for the soldier is as important as strength and should be carefully developed, particularly in awkward recruits with big, strong muscles. This is done by light but continued exercises especially directed to the suppling of joints, and calling for short, quick movements.

4. Drills should take place in the open air whenever possible, or else in large, well-ventilated rooms. The maximum time devoted to them should not exceed 5 hours a day, namely, 3 hours in the morning and 2 in the afternoon, with a sufficient number of halts, during which the men should be allowed to stand at ease, sit or lie down.

3. As a rule, the soldier should not be exercised before breakfast, or such exercise should be short, not exceeding half an hour. The best time for drill is between meals, that is, beginning about an hour after meal and stopping soon enough to allow at least half an hour's rest before the next meal. When exercise immediately follows eating, the blood which is indispensable to the proper work of the stomach is diverted to the muscles and severe indigestion may result. It is necessary to watch over the digestion and to bear in mind that any system of training which impairs the appetite is harmful. The use of alcoholic drinks, or other stimulants or tonics, before or during exercise, should be strictly prohibited.

6. The action of the heart and lungs must be closely watched, and any exercise likely to bring about pulmonary congestion or difficulty in breathing avoided. No exercise should be so strenuous as to produce severe dyspnea, while the pulse, however quick it may be, should remain regular and of fairly good strength.

7. Drills must be made as varied and interesting as possible. A long continued mechanical repetition of the same movements soon tires the recruit and renders him listless. He profits but little by exercises in which he ceases to be interested and which he performs in an imperfect and perfunctory way. Therefore the monotonous work of the "School of the soldier" and the "School of the company" should alternate with gymnastic exercises, marching, wrestling, boxing, fencing and athletic games.

Overtraining.

When, as the result of muscular exercise, carbon dioxid and other waste products accumulate in the blood, we experience a sense of fatigue. The power of the brain to generate impulses, as well as the nerve force which transmits them are weakened, and the contractile power of the muscles is impaired so that the heart beats more feebly and the arterial

tension falls. If, as the result of violent exercise without sufficient rest, these waste products continue to accumulate faster than they can be eliminated, and the oxidized tissues are not properly renovated, the symptoms of overtraining show themselves.

The most common form of overtraining is that which results from continued, hard muscular work without sufficient rest or sleep, and is not rare among soldiers during the period of instruction, maneuvers, practice marches, and especially during a campaign. Its symptoms are constant lassitude, with drawn, haggard face, impaired appetite and disturbed digestion, loss of weight and strength, fall of temperature; the heart is somewhat dilated and the pulse soft and quick, while the cyanosed skin and mucous membranes indicate a sluggish circulation. In this so-called "stale" state, soldiers become an easy prey to infectious diseases, especially typhoid fever and tuberculosis.

In another form, the result of a more strenuous but less prolonged exertion, the overtrained men suffer from myalgia, lumbago, general stiffness and well-marked febrile symptoms, with coated tongue, gastric disturbance, headache and insomnia. These symptoms usually last a few days and disappear, but sometimes, in more aggravated cases, the patient falls into a typhoid state, the so-called overtraining fever (fièvre de surmenage) which imitates true typhoid, being distinguished chiefly by the normal condition of the respiratory organs, the weak, dilated heart, cardiac dyspnea, and the small, soft, irregular pulse.

In the so-called overstrain, occurring mostly among young men taking part in athletic races and games, the symptoms are chiefly those of dyspnea, caused by the rapid accumulation of carbon dioxid in the tissues, and cardiac failure. If the athlete heeds the first warning and stops in time he soon recovers his normal condition, but if he prolongs the effort, determined to win at any risk, he is liable to the worst effects of overstrain—a hypertrophied and dilated, flabby heart, with irregular, dicrotic pulse—a condition from which he may never fully recover. In other words, the normal physiological hypertrophy of the heart becomes pathological. In such heart the persistent increase of the tension to which the segments of the aortic valve are subject during diastole induces a slow, progressive sclerosis of these segments, and eventually aortic insufficiency, causing the so-called "athlete's heart."

There is also very good reason to believe that the hypertrophied heart of the athlete, physiologically adjusted to the demands of severe training, may give him trouble in after years, when he settles down to a quieter life, especially if he fails to reduce the generous diet to which he is accustomed.

As a rule, the enlarged muscular fiber of an athletic heart degenerates gradually to its normal size and gives no trouble, but there are exceptions in which the heart retains its abnormal strength and vigor; in such men, according to Hare, the condition is comparable to that of a steamer whose engines are too strong for her hull. As noted long ago by Clifford Allbutt, the hypertrophied left ventricle slowly causes stretching and dilatation of the aorta with subsequent insufficiency of the valves the patient often not seeking medical aid until after middle life.

One of the most frequent evil effects of violent athletics, is renal congestion and overstrain. Albumen is often, if not always, found in the urine after severe and protracted muscular effort, and it would be well if this symptom were taken as a warning that renal resistance is being overcome and interstitial nephritis is impending. Those young men who, in their normal state, before training, present traces of albumen, should refrain from all athletic contests.

Gymnastics and Physical Training.*

The exercises of the gymnasium are susceptible of great variation and therein lies one of their chief advantages. It is possible so to order and combine them as to contract, to any desired degree, every muscle, tendon and ligament, thus securing suppleness of joints as well as development of tissues, for it must be borne in mind that agility is as desirable as strength. Simple callisthenics, without apparatus, can be made exceedingly useful and should never be overlooked. An objectionable tendency in the gymnasium is to give a preponderant share to the exercises of the upper extremities. The arms are vigorously trained as in suspending or supporting the body, and often made to usurp the office of the legs; they soon become greatly developed, often out of proportion to the rest of the body, this development, in professional gymnasts, often amounting to deformity, such as protuberant shoulder-blades and round back. The legs, served by powerful muscular masses, are capable of much work with little fatigue. A man who runs quickly up-stairs, or up a steep slope, performs a sum of work which far exceeds any muscular effort he is able to do in any other way during the same time.

The vital importance of chest development need not be dwelt upon; upon the size and shape of the chest depend, to a great extent, the capacity and vigor of lungs and heart. The best way to increase the expansion of

* The authorized manuals and guides for the physical training of recruits are Butts' "Manual of Physical Drill," for out-door and parade ground instruction, and Koehler's "Manual of Gymnastic Exercises," for in-door or purely gymnastic work.

the chest is to strengthen the so-called respiratory muscles, those concerned in elevating the ribs and sternum and depressing the diaphragm. It is an error to believe that this is best attained by exercising the upper extremities; experience shows that it is best attained by the exercise which compels the deepest inspiration and insures the most complete inflation of all the pulmonary vesicles; we must therefore seek to increase the amplitude and frequency of the respiratory movements. These movements depend upon the intensity of the respiratory need, while the intensity of this need depends on the quantity of mechanical work performed in a given time. The sum of work performed by a muscular group is according to the strength of this group; the legs possessing three times as much muscle as the arms can perform three times the amount of work before being exhausted. Therefore, it is chiefly by the use of the legs, as in running or ascending slopes, that the chest is to be developed.

Another advantage of gymnastic exercises is that they are easily watched, regulated and controlled, consequently free from injury or accident. Thus it is a very remarkable record that during the fifteen years the present West Point gymnasium has been in operation not a single serious injury has occurred, neither fracture nor dislocation. Furthermore, gymnastics can be carefully graded and adapted to individual wants so that overtraining is impossible. There is no question, then, that they can be made to answer fully and successfully all the physical needs of a growing youth or young recruit. They are performed at the word of command, requiring attention and prompt obedience; this, however, is not an unmixed advantage, for exercises under coercion are not always performed with alacrity and thoroughness; they are more like work than play, may become irksome and often fail to bring out will-power and nervous energy. This is why athletic games, with their greater freedom, variety and excitement, will always be a pleasant, useful and necessary addition to mere gymnastics.

For the soldier, gymnastics are not only for the purpose of developing his strength, agility and endurance, but also a means to the end of overcoming the many obstacles which, in warfare, will stand in his way. Therefore, in a complete system of physical training, they should be supplemented by those special exercises requiring knowledge, skill and self-confidence, which the soldier would be called upon to perform under the actual conditions of a campaign. These applied gymnastics have the advantage of requiring but few appliances, only such as can be improvised in a post or camp. They comprise various kinds of races, jumping

ditches, vaulting over fences, scaling walls, climbing poles and trees, walking on narrow boards placed over ditches, etc.

Circular 33, War Department, of May 6, 1908, is a compilation of purely military exercises which have been conducted throughout the Army from time to time in athletic meets, and was published as a convenient guide for the government of competitions. It consists of 91 "events" covering most of the field duties of soldiers on foot and horseback, conducted in competition, and therefore in an attractive and stimulating form.

In our Army, the question of physical culture, outside of the Military Academy, has not yet received the systematic treatment which it deserves. Gymnasiums have been established at some of our largest posts, in connection with the exchanges, but exercise therein is entirely voluntary or left to the discretion of post commanders. Existing War Department orders provide for garrison training and field training. Garrison training includes gymnastics, out-door athletics and all other military exercises practicable in garrison. Field training includes practice marches, camping and all other field work. The details of this training and the time devoted to it are prescribed by Department Commanders.

It seems to be the opinion of officers who have given special attention to the subject, that gymnastic drill should be made compulsory for foot troops and discretionary with the post commander for mounted troops, but never exceed 30 minutes each day.

SPECIAL EXERCISES.

Marching.—Marching being the most important of military exercises will be the subject of a special chapter.

Manual of Arms.—The manual of arms exercises all the muscles of the body, but very unevenly; those of the shoulders, arms and chest are much more affected than those of the lower extremities, and the right side more than the left. It is an imperfect exercise and develops quickness of movement more than strength.

Setting-up Exercises.—The six setting-up exercises prescribed in the Drill Regulations are simple, easily performed and, if all practised successively, affect all the muscles of the body pretty evenly, correcting the tendency to muscular asymmetry and defective attitudes produced by the manual of arms, bayonet and saber drills, and fencing. Each exercise should be short, as it brings into play only few groups of muscles and soon produces great fatigue.

Fencing.—This is one of the very best and most complete of military

exercises, bringing into vigorous play all the muscles of the body, expanding the lungs, cultivating agility, quickness of decision, rapid coordination and accuracy of movements. It is a violent exercise, only to be indulged in by the physically sound and which should be carefully graded. A serious drawback to fencing is that the side of the hand which handles the foil is liable to become somewhat hypertrophied, the muscles of the shoulder, arm and leg on that side growing larger and stronger; as a consequence there may also be some degree of lateral curvature, with concavity toward the foil hand. This danger is prevented or corrected by fencing with the left as well as the right hand.

Sword and saber exercises are similar in their character and effects to fencing. In bayonet exercise, both arms being employed the muscular exertion is more evenly distributed.

Running Drill.—This drill, like double-time, is prescribed by infantry regulations and forms part of the soldier's training, but it is a violent exercise requiring careful supervision. At first, the soldier should run in light garb and without encumbrance; later, his arms, canteen and blanket-roll may be added. The distance is gradually increased until it reaches a maximum of 200 or 300 yards. To avoid the danger of overstrain, men running, especially in competitive races, should be allowed to fall out at will; men with signs of cardiac weakness should not be allowed to run at all.

Equitation.—Equitation brings into play the muscles of the basin and the lower extremities, while it has but very little effect upon the upper extremities and chest. Therefore it is an imperfect exercise and must be supplemented by gymnastics. The continuous shaking and jolting to which are subjected the abdominal viscera, if not excessive, have a beneficial effect and tend to improve digestion and nutrition. This exercise should be practised in open air, whenever the weather permits, so as to avoid the breathing of the more or less infected tan-bark dust of the riding-hall.

The dangers of equitation are the production of hernia, ptosis or displacement of various abdominal organs, and hemorrhoids. It has been accused, but without proof, of causing varicocele and varicose veins. The mounted soldier is particularly liable to furuncles and ecthyma in the region of the buttocks, the result of local infection; daily washing and clean linen will prevent their occurrence. Chafing and excoriations of the thighs and buttocks are more or less inevitable in recruits; they should be washed with boiled water and dressed with antiseptic gauze.

Swimming.—Swimming is a useful accomplishment as well as a capital

exercise, and wherever possible should be practised by the recruit. It produces contraction of all the muscles of the body, as well as free expansion of the lungs, under the best possible conditions. It has, furthermore, the added advantage of the marked tonic effect of cold water, while the skin is thoroughly cleansed. It is somewhat violent, and should be carefully graded to the cardiac strength and power of endurance of each man. A non-commissioned officer, or Hospital Corps man, well instructed in the care to be given cases of asphyxia by drowning, including artificial respiration, should always be on hand with the necessary outfit.

To secure the best effects and prevent the dangers of swimming, the following indications will be found useful:

Salt water is best, but if a river or pond be used the water should be reasonably clear and free from organic filth, and the temperature not below 65° or 70° F.

Do not enter the water while perspiring very much or when chilled, or too soon after eating; the best time is a couple of hours after meal.

On entering the water, submerge the whole body, including the head, and begin swimming at once to prevent chilling.

Diving and swimming under water may injure the ear-drum or otherwise affect the hearing, and therefore should be avoided by men whose ears are not perfectly sound.

Leave the water before feeling exhausted or very cold, and before the legs and feet show signs of numbness.

After the swim, dry the skin thoroughly to restore circulation and prevent chilling.

Athletic Games and Races.

Games and races, such as football, baseball, basket ball, la crosse, cricket, tennis, running and rowing, provide the natural and most pleasant forms of exercise. They should therefore always form part of a well-regulated system of physical training and, when kept within proper bounds and intelligently supervised, receive every encouragement. There is no doubt that the best effects of exercise can be obtained from them, *provided the contestants are physically sound and properly trained.*

Athletic games give useful results in the Army only in so far as all recruits are permitted and encouraged to indulge in them, that is, when the games are practised in a general systematic way, for the benefit of all. To pick out a team in a garrison from a few exceptionally strong men and train them for a contest with a similar team from another garrison may lead to pleasant and exciting diversions, and to that extent is unobjection-

able, but such training and contest add practically nothing to the physical efficiency of the company or regiment concerned. This tendency to make spectacular displays of athletic games is one of the most serious objections urged against them, for instead of an average gain among all the men, the great majority of them are allowed to be simple idle spectators while a small minority are strenuously trained, even to the point of danger. It is doubtful whether those who participate in these contests derive from them any physical benefit which they would not more fully obtain from ordinary gymnastics. Thus it was found that at the United States Military Academy, the football players of the graduating classes of 1900, 1901, 1903 and 1904 only increased 4.36 pounds in weight during their stay at the Academy, while the average increase for the four entire classes was 5.62 pounds.

For these reasons the War Department has wisely decided that athletic "meets" between posts should not be encouraged, although they may be permitted once a quarter between the units of the post.

Football.—Of football, as it affects body and mind, there is a great diversity of views. That it is a dangerous game, attended with many injuries of all degrees of severity, is generally admitted. As regards mere physical development, better results can be obtained by graded gymnastics and less strenuous games. At the United States Military and Naval Academies, as well as all other educational institutions, it is detrimental to intellectual culture for the following simple reasons:

1. It absorbs time which the athlete should devote to his books. His leisure hours are no longer his own; he must train and practise as bidden, whatever may be his class standing and need of study.

2. It produces intense fatigue. An exhausted body means a tired mind, one incapable of useful study. Each game involves the expenditure of an enormous quantity of nervous energy, and time is required to recuperate.

3. It causes many injuries, from which, indeed, the athlete generally recovers but for which he must be treated in hospital for days, weeks or months, valuable time irrevocably lost to him.

The effect of football on character is noteworthy. It is obvious that the qualities which it demands and develops: attention, subordination, self-restraint, clear judgment, prompt decision, pluck, etc., are precisely those most needful to the officer on the battlefield. Therefore it seems a logical conclusion that this game, although somewhat dangerous to the body and rather seriously interfering with the curriculum, may be tolerated, if not encouraged, at the Military and Naval Academies, not indeed as a means

of physical culture but rather as a means to develop useful military traits of character.

From what precedes it does not follow that football is suited to soldiers and sailors. Most of them have not received the thorough training which is indispensable, and, at their age, such training is hard and often impossible. Furthermore, they are less capable of the self-control and subordination absolutely necessary for a clean game. The result is that when soldiers play football the casualties are likely to be many and serious.

In colleges and other institutions, not military, the serious objections existing against football, as now played, are not offset by compensatory advantages and the game should be completely banished from them.

CHAPTER X.

THE MARCH.

Maurice of Saxe taught long ago that it was much more important to exercise the legs of the soldier than his arms, that in his legs was the secret of the success of a campaign, and that ability to march was far better than knowledge of the manual of arms. Napoleon is credited with the saying that battles are won with legs rather than with arms. In modern warfare, everything tends to indicate that victory will continue to be with the commander who gets first in position with the largest number of men.

Marching is the normal exercise of infantry. It is the simplest, easiest and most important of all military exercises, but also the most exhausting on account of the enormous amount of muscular work performed, especially when the soldier carries his equipment, arms and ammunition. The infantry man, therefore, should be constantly and persistently trained in marching, with and without his load, until he is able to walk 15 to 20 miles a day, with arms and equipment, without much fatigue, almost automatically.

Any march exceeding 20 miles in 24 hours is a forced march, but soldiers in good training should always be able, when circumstances require, to make a forced march of 25 or more miles. "The maximum for a day's march of infantry and trains may be assumed at 28 to 30 miles; a repetition of this performance on the next day cannot be counted upon unless conditions are quite favorable" (Field Reg.). One of the most remarkable forced marches on record is that of Friant's division which covered 78 miles in 46 hours, and the next day (December 2) fought in the battle of Austerlitz, in which it lost 40 per cent. of its strength in killed and wounded.

During the period of the year assigned especially to practical instruction, as determined by Department Commanders, existing orders direct that there will be "one march in each month of not less than three nor, ordinarily, more than six days, and during such period commands will take the field for not less than twenty-one consecutive days."

According to our Regulations, the length of the full step, in *quick-time*, is 30 inches measured from heel to heel, and the cadence at the rate of 120

steps per minute. The foot is moved smartly, but without jerk, straight forward, sole near the ground, the knee straightened and slightly turned out; at the same time the weight of the body is thrown forward and the foot planted without shock. The arms hang naturally, the hands moving about six inches to the front and three inches to the rear of the seam of the trousers.

In *double-time*, the length of the full step is 36 inches and the cadence at the rate of 180 steps per minute. The hands are raised until the fore-arms are horizontal, fingers closed and elbows to the rear. The knees are slightly bent and the arms allowed to swing naturally.

In the *route-step*, the men are not required to preserve silence nor keep step, but the ranks must cover and preserve their distance.

In European armies, the quick-time step is the same as in our service, except that in Germany it is 31 1/2 inches with cadence of 115 steps per minute, and in Russia only 28 inches. According to Marey, the length of the step increases with the cadence up to 150 steps per minute and then diminishes. It is generally recognized that better results are obtained by lengthening the step than by accelerating the cadence; this is done by inclining the body forward, completely extending the rear leg and flexing the front one.

In the double-time step there should be no hopping movement, the center of gravity being maintained as much as possible along a horizontal line; the leg should be flexed as the foot strikes and the foot set flat upon the ground.

The military step is more fatiguing than the ordinary walking step; the movements are more rigid and constrained, ease of carriage being sacrificed to precision and uniformity. The body is erect and the legs extended or only slightly flexed, the heel touching ground first, followed after an appreciable interval by the toes. The progression of the body is attended with a succession of vertical and lateral oscillations very conspicuous in a regiment of marching troops, the body rising as each foot is lifted from the ground, and swaying to right and left as the corresponding foot is set down. The vertical oscillation often reaches an amplitude of two inches, a useless waste of effort.

The military step, therefore, however desirable on the parade ground and on occasions of ceremony, is not suited to marching in the field. To render it less irksome and fatiguing, the body should be slightly inclined forward, but with head erect and chest thrown out to favor breathing; the foot moves parallel with the ground and nearly straight forward, being raised only just enough to clear obstacles; the muscles of the knee are

relaxed as the foot strikes ground (heel and toes almost simultaneously) to prevent shock. The feet should be slightly turned out to increase the base of support, but this eversion must not exceed an angle of 10 or 12 degrees so that the foot may rest in its normal position, namely, on heel, ball and outer edge; beyond this, there is a waste of muscular effort and the foot is made to rest too much on its inner edge, with danger of straining and flattening the arch. Under instruction, the vertical and lateral oscillations of the body can also be reduced to a minimum.

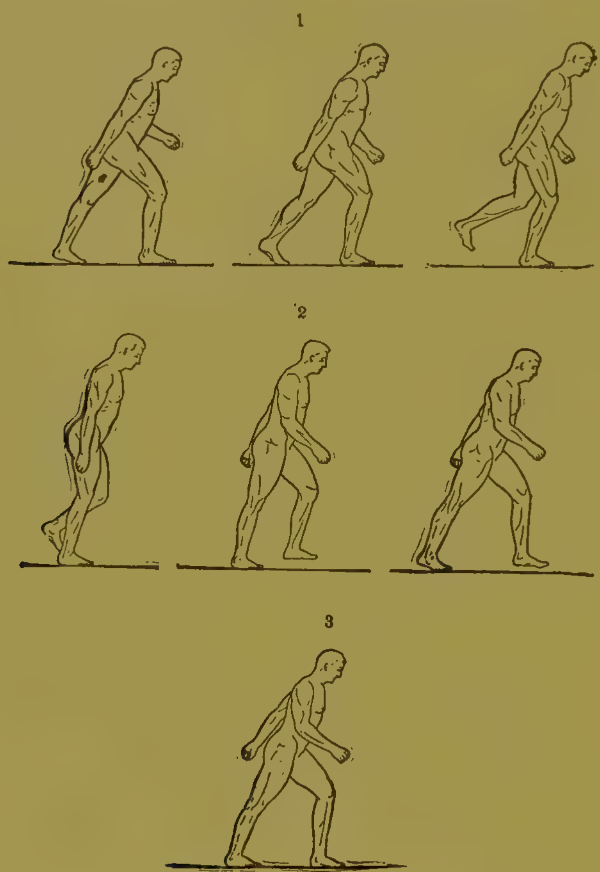

FIG. 20.—Flexion march (*Bradford*).

Flexion step.—Carrying these indications still a little further, we obtain the "flexion step" of the French as developed by De Raoul, said to be the most natural route-step, and the best to cover long distances with the least fatigue. It is that generally taken by tired laborers, messengers and mail-carriers. In this step the body is bent; the hips, knees and ankles are flexed; the feet just clear the ground and move parallel with it, being planted flat, heel and toes together. By leaning the body forward, the

center of gravity is displaced and the legs follow with the least muscular effort; the greater the inclination forward the greater is the speed. This step, it is claimed, enables trained soldiers to cover a distance of 10 miles in about 1 hour and 45 minutes, with less fatigue than in double the time with the ordinary step. Against it the objection has been made that the continuous extension of the quadriceps femoris (fleshy mass in front of the thigh) will ultimately cause a larger expenditure of muscular work than in the ordinary walk. A useful modification, suggested by Demeny, consists in fully extending the rear leg which thus helps materially in increasing the length of the step and propelling the body forward. (Fig. 20).

Regulation of the March.

The length of the average march for infantry and for mixed commands consisting partly of foot troops, is 15 miles per day, with a day of rest at least once a week. Small commands of seasoned infantry marching on good roads in cool weather can cover 20 miles per day, but in extensive operations involving large bodies of troops, the average rate of progress will not exceed 10 miles per day. Field artillery marches 15 to 20 miles a day; cavalry, after men and animals are hardened, 25 miles a day; wagon trains about the same as infantry. (Field Reg.).

It is of great importance that an even, uniform rate be maintained throughout the column, so as to avoid the alternate checking and hurrying produced by an irregular pace, so fatiguing for the body and trying to the temper. In the field the maximum rate to be counted on, while marching, is 3 miles per hour, and, including halts, 2 1/2 miles per hour. "Sandy, muddy or slippery roads, great heat and dust, strong head winds and storms, or broken country reduce the rate of progress." Under average conditions the rate for infantry columns may be assumed at 2 1/4 to 2 1/2 miles; thus, for a march of 15 miles, a period of 6 to 7 hours is necessary.

After marching half to three-quarters of an hour, the column is halted for fifteen minutes to allow the men to relieve themselves and readjust their clothing and accoutrements. After this first rest there should be a halt of ten minutes every hour, that is, the troops march fifty minutes and then halt ten. This is not a rigid rule and may be modified according to circumstances.

Men on the march should not breathe hurriedly, but regulate the number of inspirations to the cadence of the step, taking a deep breath every few respirations in order to fill all the air-cells and secure thorough oxygenation of the blood. The air should be inhaled through the nose as

far as possible, but, in hard marching, most men are obliged to breathe through the mouth as well.

It is advisable to start slowly so as to gradually supple the joints without fatigue and get the second wind established without breathlessness. It is likewise well to slow the pace at the end of the march so as not to get into camp in a heated and perspiring state. Halting places should always preferably be on clean, dry ground, sheltered from the sun in summer and from the wind in cold weather. If the ground is wet the men should not sit or lie down, unless they can do so on their ponchos or other water-proof material. In difficult or mountainous country, halts should be more frequent. If the march be unusually long, a rest of about one hour is necessary after covering two-thirds or three-fourths of the entire journey, during which the men may eat a light meal.

"When the roads are soft with mud or deep with sand, it may be advisable to divide the column longitudinally, thus permitting men and animals to pick their way with better footing and leaving the middle of the road clear. The suffering from heat and dust may also be materially reduced by this method. But, whatever the widening of the column thus produced, increase of length of the road space occupied by any unit should not be permitted" (Field Reg.).

In hot weather the men should be allowed to remove their coats or blouses, or at least to unbutton them so as to promote free evaporation of perspiration.

The march should begin at as early an hour as possible so that the men may arrive at their destination by noon or as soon thereafter as practicable. In hot weather or in a tropical climate, an early start is still more necessary; then the march may even begin before daylight, being intermitted at 9 or 10 o'clock and the men allowed to rest until 4 or 5 o'clock, when it is resumed. Night marching is very exhausting and justifiable only in emergencies.

The men should breakfast before starting, fill their canteens and carry their luncheon in the haversack. All forms of alcoholic drinks are pernicious and must be strictly prohibited. As little water as possible should be drank, and only during the halts; free water drinking produces profuse perspiration, gastric disturbance and is distinctly debilitating. It is largely a matter of personal habit, against which the men should be cautioned. Furthermore, there will often be some uncertainty as to the quantity and quality of the next water-supply, and the thoughtful soldier always keeps a reserve in his canteen. Smoking and chewing are injurious during the march and should be postponed until the camp is reached.

The chewing of a twig of some bitter shrub or of a piece of bark is recommended, as it excites the salivary secretion, keeps the mouth and throat moist and relieves the sensation of thirst. Weak tea or coffee in the canteen is much better than water; it is a sterilized, gently stimulating drink and less of it is necessary to quench thirst. Sugar is a special tonic and restorative of the muscular system and may be used freely either in coffee or tea, or in the form of chocolate tablets. The sources of water along the route must be carefully investigated by medical officers marching with the vanguard and, so far as possible, their quality (whether potable and safe, or otherwise) indicated on conspicuous posters. The character of any water, under such conditions, can only be determined hurriedly and approximately by taste, color, smell, surroundings, depth of well, opinion of inhabitants, etc. The men should be forbidden to drink from unauthorized supplies.

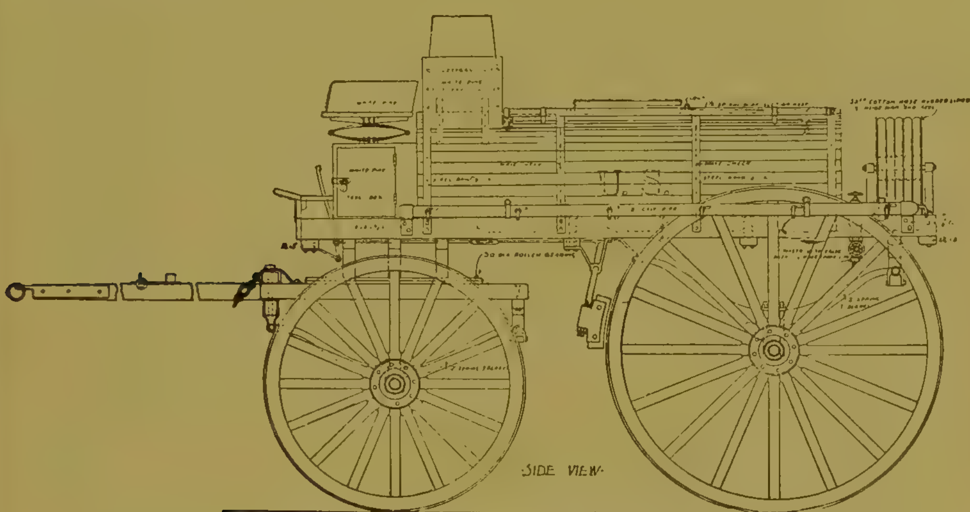

FIG. 21.—Army water wagon, with pump, hose and distributing pipe.

Before crossing desert tracts where water is scant and of bad quality, a sufficient quantity of good water should be taken in barrels or in specially constructed carts. The army water wagon recently adopted by the Quartermaster's Department, of a capacity of 225 gallons (Figs. 21, 22) fills a long-felt want and will doubtless prove very useful under such circumstances.

CARE OF FEET.—As the result of marching, the feet are liable to various injuries, such as corns, blisters, ingrown nails, excoriations or abrasions, periostitis of the metatarsal bones, synovitis of tendons, tarsalgia, etc., which may be followed by lymphangitis and adenitis. When walking over rough ground, with heavy equipment, there is also a liability to sprain

or fracture of metatarsal bones, usually the second, an accident attended with considerable swelling and pain. These injuries are prevented or mitigated by the use of well-fitting, comfortable shoes, rendered soft with grease or oil, and by cleanliness. The feet should be washed every day by immersion in cold water, but only long enough to remove the perspiration and dirt and relieve the sensation of heat and fatigue; long soaking softens the skin and does more harm than good. It is a good plan to change shoes every day or two; stockings which are soiled, wet or wrinkled should be replaced by a clean pair as soon as possible. Careful greasing of exposed or painful parts with fresh tallow, lanoline or vaseline, is advisable. It is also recommended to soap the feet or dust them with talcum powder, before starting, to diminish friction. Parts exposed to friction may be protected by wide strips of adhesive plasters. Talcum

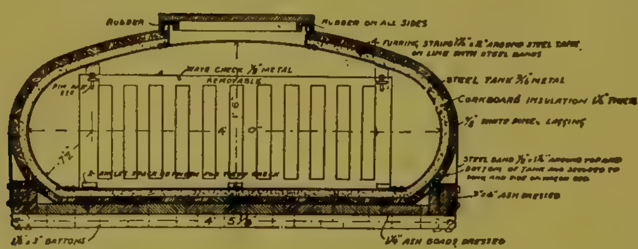

FIG. 22.—Section through tank of Army water wagon.

powder is useful as a lubricant and antiseptic, especially with the addition of salicylic acid (talcum 87 parts, starch 10 parts, salicylic acid 3 parts), as used in the German Army. Tender feet can be hardened by bathing them in alum, lead water, or diluted alcohol. Corns should be pared down and protected with corn plasters; more radical treatment must be reserved for the hospital. Blisters are pricked with a needle, gently squeezed, then protected with adhesive plaster or bandage. Toe nails are not so likely to become ingrown if cut square across or only slightly rounded, and not too close.

IRRITABLE HEART.—This condition, a form of heart strain, is seen in young, immature and untrained soldiers, and appears to be the result of temporary dilatation and failure of the right heart, under severe and steady marching. There is more or less exhaustion and shortness of breath; the action of the heart is short, irregular and "irritable," that is, greatly quickened by the least exertion, and is often attended with a murmur; the pulse is weak, intermittent, quite variable in frequency, sometimes dicrotic. The treatment is complete rest, under which the patient ultimately

recovers, but although there is no indication of valvular disease the irritable cardiac action usually persists for a long time.

For sunstroke, heatstroke and heat-exhaustion, see under *Service in Warm Climates*.

WORK DONE IN MARCHING.—It has been ascertained that an ordinary day's work for an adult is equivalent to about 300 foot-tons, a hard day's work to 400, and a very hard day's work to 500 foot-tons. From the investigations of Haughton, Rubner and others, it is also possible to estimate the amount of labor performed by men in marching. According to Haughton, as quoted by Harrington, this labor, in walking over a level surface, is determined by the following formula:

$$\frac{(W+W')\times D}{2240}\times C = \text{number of foot-tons.}$$

W = weight of the person.
W' = weight carried.
D = distance in feet.
2240 = number of pounds in a long ton.
C = coefficient of traction.

The coefficient of traction varies for different rates of speed. For two, three, four and five miles per hour, it is approximately 1/26, 1/20, 1/16 and 1/14 respectively. Thus a man weighing 160 pounds, carrying 40 pounds and walking 15 miles at the rate of 3 miles per hour, will perform an amount of work equivalent to 353.57 foot-tons:

$$\frac{(160+40)\text{x } 79200}{2240}\times\frac{1}{20} = 353\cdot57$$

or, if at the rate of 2.5 miles per hour, 307.45 foot-tons.

The nature of the terrain has naturally very much to do with the amount of exertion required; a very muddy, sandy or dusty road enormously increasing the work of the soldier. He may even be obliged to give up the road to the wagon trains and pick his way alongside of it. A gently rolling country is better for him than a flat surface, as all the muscles concerned in locomotion are alternately brought into action and rested. The expenditure of energy is generally greatest when marching over rough and ascending ground. If, furthermore, we consider that, in the field, marching is only part of the day's work of the soldier, that he must also pitch and strike camp, load and unload wagons, do guard duty, etc., we realize that an average daily march of 15 miles, with full equipment, cannot be long exceeded without danger of overstrain and of seriously impairing his efficiency.

CHAPTER XI.

PERSONAL HYGIENE.

The mode of life of the soldier who, in camp or in garrison, is constantly thrown in contact with his comrades, renders personal cleanliness and good sanitary habits especially necessary.

We bathe and wash the skin:

1. To promote and stimulate its physiological functions. These functions are of great importance. The skin, besides being the seat of the sense of touch, is an excretory organ, pouring out from one and a half to over four pints of sweat daily, and the regulator of the body temperature. It also contains numerous sebaceous glands yielding a semi-fluid, greasy substance which forms a tenuous lubricating film over many parts of the body. The sweat holds only one to two per cent. of solids consisting of sodium chloride, fatty acids and, in case of disease of the kidneys or liver, some of the waste products normally eliminated by these organs. The evaporation of the sweat, that is, its conversion into vapor, can only take place by the absorption of heat, chiefly from the skin, so that the more rapid the evaporation the more active the cooling of the skin and the greater the reduction of the body temperature. Washing the skin, therefore, opens the pores or mouths of the sweat glands and promotes free perspiration, especially during muscular exercise when the temperature tends to rise. It also stimulates the sebaceous glands; but, on the other hand, repeated bathing, when accompanied by hard rubbing may remove their secretion more or less completely and cause dryness of the skin; this, however, is seldom to be apprehended.

2. To remove dirt and prevent the breeding of germs on its surface. The dead superficial layers of the outer skin or epidermis are constantly thrown off and, together with dried sweat, sebaceous secretion, dust and other outside impurities, form, if not washed, a foul coating which affords an excellent soil for the growth of microbes; Remlinger has counted 40,000 on a square centimeter of skin; not infrequently they cause prickly heat, furuncles, ecthyma, cellulitis, whitlow, etc., in persons careless of their personal habits. Any wound of a dirty skin is also much more likely to become seriously infected. It is well known that several of our most prevalent and dangerous infectious diseases, such as typhoid

fever, cholera and dysentery, are often propagated by personal contact, that is, through the conveyance of infected excretions on skin and clothing, but especially on the hands; hence the increased necessity, in the presence of one of these infectious diseases, to bathe and wash frequently.

3. To prevent fouling of the air by emanations resulting from the accumulation and decomposition of excretions and filth.

4. For the tonic and stimulating effects which cold water produces on the terminal filaments of nerves and, through them, on the whole nervous system.

Daily Toilet.—Every man should wash his face, head, neck and hands every morning, in cold water. Tepid water is better for cleansing purposes and, if available, may be used, but should always be followed by cold water. Although it is well for the scalp to be washed every day, soap should not be used upon it more than once or twice a week for fear of removing too completely the oil which nature provides, and making the hair dry and brittle. The hands should be washed with soap, whenever soiled, before each meal, and the nails frequently cleaned and brushed.

The soap used on the human skin should preferably be neutral in reaction, with potash base and a slight excess of fat ready to combine with the alkali set free as the soap is dissolved (Unna). The water should be soft, that is, as free from lime and magnesia as possible; the addition of a little lime-water, soda, glycerine, bran or starch renders hard water less objectionable. Soap does not only act as a detergent in removing dirt, but has also considerable bactericidal power and is therefore a useful disinfectant for the skin as well as for soiled linen. This action does not appear to be due to either the alkali or the fatty acid of the soap but to the combination of the two.

The mouth and throat, particularly when the seat of catarrh, ulcerations, abscess, etc., should be frequently sprayed, rinsed or gargled with solutions of boric acid, borax, bicarbonate of soda or chloride of sodium; Dobell solution is a popular and very efficient preparation for the purpose.

The teeth demand especial attention. As soon as they give indications of decay the care of the dentist must be sought so that they may be saved if possible. The preservation of teeth means better health and probably increased longevity. Tooth-picks should never be of metal and must be used gently, lest the gums be wounded and become infected. The tooth-brush is necessary but should be comparatively soft. Hygienic tooth-powder should contain as little hard and insoluble matter as possible in order not to bruise the mucous membrane, or lodge between the teeth; ordinary alkaline soap is preferable.

The nostrils require some care; they can be sprayed daily with Dobell solution, or else liquid vaseline or a tepid solution of common salt may be snuffed up. The frequent snuffing of cold water is not advisable.

The ears collect much dirt and should receive their share of the daily toilet. Considerable wax is often secreted at the mouth of the auditory canal and should be removed at least once a week; this is best effected with a little absorbent cotton or gauze wrapped around the point of a little wooden stick or tooth-pick and dipped in tepid water or diluted alcohol; the parts must be wiped dry afterward. To push the stick deep into the canal is unnecessary and dangerous.

The beard, if worn at all, should be neatly trimmed, brushed every day and frequently washed. It is best for the soldier, at least when in barracks, to shave the whole face, although the wearing of the mustache, if properly clipped, in unobjectionable.

The hair should be kept short, less so in the tropics, and for its ordinary daily care needs nothing more than comb and brush. Let the brushing be free but not so hard as to scratch or irritate the scalp. Once or twice a week it may be shampooed with soap or an alcoholic lotion.

It is well known that contagious diseases, such as syphilis and various skin affections (tinea, favus, acne, impetigo, forms of eczema, etc.) can be conveyed by the hands, instruments and implements of the barber. Every soldier, therefore, should endeavor to shave himself. But as this cannot be enforced, post barbers should be required to keep their shops and their persons scrupulously clean and take such sanitary measures as will prevent the transmission of disease. For the disinfection of shaving mugs, scissors, razors and brushes, boiling water is efficient but somewhat difficult of employment. Alcohol followed by a solution of formalin (4 per cent.) or tricresol (1 per cent.) is preferable. Powder puffs should be replaced by wads of gauze which are thrown away after being used.

It is imperative that each soldier should have his own toilet articles, such as soap, brushes and towels; if he does not shave himself he should have his own mug, shaving-brush and razor in the barber shop. The use of toilet articles in common is very repugnant to cleanly men and insanitary; it should be strictly forbidden.

The feet get soiled very quickly, not only from outside dirt but also from their own secretions, the product of numerous sweat and sebaceous glands. These secretions, especially between the toes, unable to escape, collect and soon form a culture medium for many micro-organisms, some of which produce the repulsive smell so noticeable in certain individuals.

Furthermore, the retained sweat soaks the epidermis, softens it and renders it more liable to rapid abrasion.

The feet should be washed whenever the body is bathed, that is, at least twice a week, but whenever convenient facilities exist it is a good practice to wash them in cold water every morning. Soldiers who do much walking or marching, especially in the field, should bathe them every afternoon, after getting into camp, as already noted. In case of great tenderness of the epidermis, very little soap should be used, and only cold water, to which alcohol or an astringent can be added. It may even be better to use simply a wet cloth. Sweating feet, or feet emitting

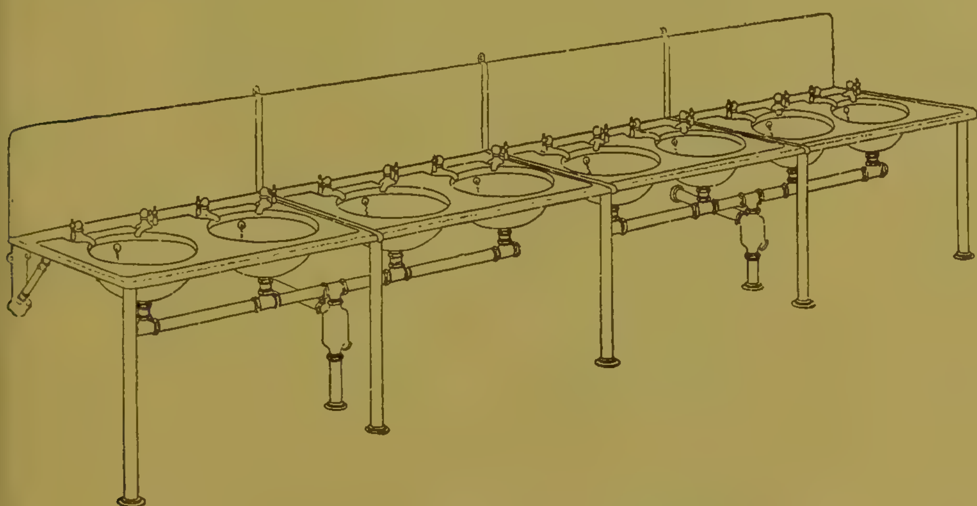

FIG. 23. Lavatory bowls. Quartermaster's Department type.

a fetid smell, even when clean, may be powdered with equal parts of boric acid and bismuth, or else occasionally dipped in a 3 per cent. solution of formalin.

Each company, in our posts, has its own lavatory which, besides water-closets and urinals, contains wash-bowls, shower-baths, laundry tubs and sinks, with all necessary plumbing fixtures (Fig. 109). The bowls are of porcelain and supplied with hot and cold water (Fig. 23). There should be at least one for each five men. They may be thus safely used in common if kept scrupulously clean; it is always desirable, however, that one or two in each company be reserved for men suffering from contagious affections. Any man who so desires can use a removable individual basin. A very useful addition to the lavatory would be a special porcelain or zinc-lined trough set up a foot and a half above the ground to enable the men to wash their feet at any time.

Soap is furnished by the Subsistence Department, therefore each man should be required to have and use his own piece. An excellent sanitary and economic device, already well known in this country, and especially adapted to garrisons, is that illustrated in Fig. 24, in which as much of the soap as necessary is grated off by turning a crank, without any handling of the cake.

BATHING.—The short morning bath is the rule for everybody who can do

FIG. 24.—Soap granulator in use. (Hygienic Soap Granulator Co.)

so. The soldier can seldom enjoy this luxury, nor is it necessary for cleanliness, but whenever the facilities are adequate he should be required to bathe the entire body twice a week.

A bath can be taken at various temperatures. It is cold when ranging from 40° to 80° F.; tepid, from 80° to 90°; warm, from 90 to 100°, and hot when above 100.° The water has also different effects according to its temperature; thus for cleansing purposes warm water should be used, while if a bracing, tonic effect is desired the cold bath is indicated. The

benefit of both cleansing and tonic effects can easily be obtained by following the warm bath by a cold sponging or shower, or a plunge into cold water.

That the cold bath, either with sponge, in tub or as shower, has a decided strengthening effect is undoubted and therefore should be preferred by those who can safely take it. Not only is it a general tonic, but it also hardens the peripheral nerves and enables them to stand exposure with greater impunity, so that the cold bather seldom contracts affections of the nose, throat and bronchial tubes. The shock of the cold bath is severe and cannot be borne by every one; it is positively dangerous for men with cardiac weakness or degenerate arteries. The test of its usefulness is in the immediate after-effect which should be a pleasurable sensation of warmth and increased energy. Should the bather, on the contrary, remain chilly and depressed, he should abstain. Cold sponging can often be enjoyed by delicate persons if standing with feet in tepid water.

The warm bath dilates the skin capillaries and causes free perspiration. It has a general soothing, relaxing and sedative effect, removing the soreness of tired muscles and restoring sleep in insomnia.

The Turkish bath and the Russian bath are taken in air heated to a very high temperature (120° to 150° F.), dry in the former, moist in the latter; the body is vigorously rubbed and massaged, then bathed in warm water, and the process ends with a cold douche or plunge, and thorough drying. Either Turkish or Russian bath is somewhat severe and should be carefully tried and adjusted to the resistance of the individual. It produces a perfect cleansing of the surface, abundant elimination of waste matter through the profuse sweat, and relieves internal congestion. It is especially useful to well-fed men of sedentary habits and therefore seldom needed by soldiers.

In the Army, the ordinary tub bath is inconvenient, expensive and insanitary, and should seldom be seen outside of post hospitals. It is being entirely superseded by the shower bath which has superior advantages and none of its objections. The shower bath requires a simpler, more easily handled apparatus, and consumes much less water and time. With it the transmission of disease, not unlikely in a tub, is made impossible. Moreover, the percussion of the water upon the body intensifies the tonic effects of the cold water. To get the full benefit of this percussion the nozzle should be movable so that the shower may be projected at any angle. Although both warm and cold water are provided, the men should gradually accustom themselves to cold water, at least in summer;

but warm water, whenever used, must always be followed by cold water, or as cold as can be borne.

While bathing, the soldier should give special attention to the hairy parts of the body, under the arms and about the genitals and anus. The secretions from the mucous membrane of the prepuce, particularly in men with long foreskin, soon become acrid and irritating and should be regularly washed out. The skin around the anus, as well as the anus itself, especially in case of hemorrhoids, must also be thoroughly cleansed.

LAUNDERING.—But little benefit will be derived from washing the body if the linen in contact with it and constantly absorbing its secretions is not frequently changed. Underclothing wet with perspiration should be removed and dried at the first opportunity, before being worn again. No man, while in barracks, should be permitted to go to bed in the underclothing worn during the day. Each soldier is expected to provide himself with two or more sets of pajamas for night use.

In the process of laundering, the linen is first soaked in cold or tepid water, then placed in hot or boiling water, with soap, and finally rinsed out. The water in which it is first soaked becomes charged with a large amount of organic filth, including much more germs, according to Miguel, than are contained in ordinary sewage. This polluted water is therefore particularly dangerous and must be disposed of in such manner that it will not contaminate the soil nor the water-supply. Clothing which is boiled is thereby disinfected, that is, freed from all ordinary pathogenic germs. Boiling, however, does not remove the ill-smelling organic dirt, especially from woolen articles, imparted by an unclean skin; this must be done by subsequent rinsing in running water or pure water frequently changed. Properly laundered clothing, when tested by the nose, should have no other than a clean, sweet smell.

In our garrisons there is no general regulation governing the washing of clothing. A few laundry tubs are provided in the lavatory of each company for the washing of such articles as men may find necessary to do (Fig. 25). Each soldier is expected to have his own laundry done as best he can, sometimes at much inconvenience and expense. The weekly wash thus received from various outside places is always a source of danger since it may introduce vermine and disease germs into the garrison. It is therefore highly desirable, as a sanitary measure as well as for the convenience of the men, that the laundry work should be done under official supervision, either in connection with post exchanges or by means of properly equipped post steam laundries. The Act making appropriation for the support of the Army for the fiscal year 1908, provides "for the con-

struction, operation and maintenance of laundries at military posts in the United States and its island possessions" by the Quartermaster's Department. This is a step in the right direction and may lead to a complete solution of this vexed problem.

In the field, the cleanliness of clothing must not be neglected whatever may be the difficulties in the way. It is well known that some of our most dreaded camp diseases result from the conveyance of infectious matter from man to man by the skin and clothing. Therefore, in the absence of special provision for the purpose, each man must be required to wash and boil his own linen in camp, the only material needed being water,

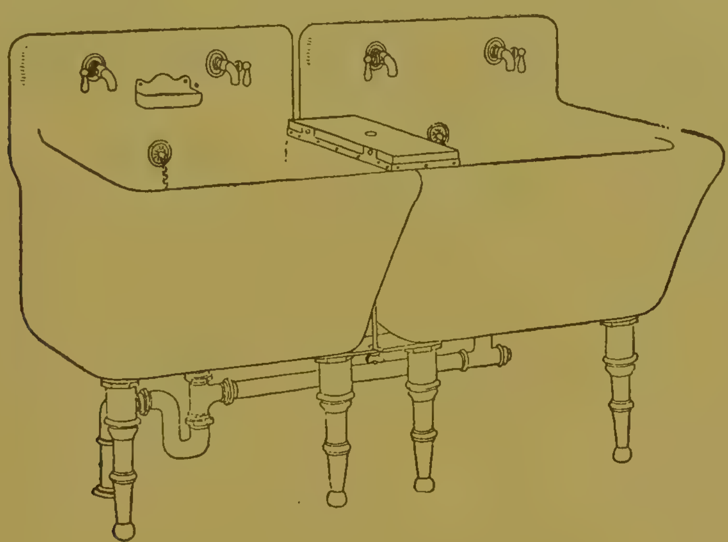

FIG. 25—Laundry tubs. Quartermaster's Department type.

kettles to boil it in, and soap. Every precaution, however, must be taken to secure the proper disposal of the waste water. When a command is camped on a stream, the part used for washing should be the lowest, or the farthest removed from that used for drinking purposes..

SKIN PARASITES.—Skin diseases, the result of parasites, formerly rather common in our army, are now seldom seen. True itch, or scabies, is becoming rare. In the tropics, the so-called "dhobie itch" is not uncommon among our soldiers; although applied to various itching, ringworm-like affections, it most commonly refers to some form of bacterial disease of the crotch or arm-pit. "Camp itch" is an indefinite term applied to various itching skin affections, generally beginning with papillary inflammation which, when complicated with filth and scratching, may become eczematous; its treatment should always begin with water and soap.

Of insect parasites, lice are the most loathsome but also the most easily gotten rid of. It has not yet been proved that they transmit any disease but it cannot be denied that they may do so. Three species have their habitat on man, the head louse, the body (or clothes) louse and crab-louse. Any soldier infested with either kind should be promptly isolated and subjected to vigorous treatment. In case of head infection, the hair is cut very short, shampooed and washed with a solution of corrosive sublimate (1/1000) or of formalin (4/100). The body louse is destroyed by disinfecting the clothing in steam or formalin, or boiling it in water. Insect powder may be used on outside garments. The crab-louse inhabits the pubic region; the parts should be shaved and then treated with mercurial ointment or coal oil.

CHAPTER XII.

WATER.

Water is necessary to all animal and vegetable life. In man it forms over 60 per cent. of the weight of the body and is indispensable to the ingestion and absorption of food and the maintenance of the normal composition of all our tissues. The water of the body being constantly excreted through the skin, kidneys and intestines, and exhaled through the lungs, must be constantly replaced. To supply this loss, from 70 to 100 ounces are consumed daily, about one-third of which is contained in our food.

The quantity of water required for all the ordinary needs of the body may be liberally computed in gallons as follows: For drinking, 1; cooking, 2; ablutions, 2; laundry, 8; water-closet, 6; shower bath, 5; total, 24 gallons. Where strict economy is necessary, one-half this quantity, or 12 gallons, may be made to answer the purpose. So much water however is wanted for needs not directly connected with the human body, namely, for animals, street watering, fountains, factories, etc., that the minimum daily supply per man in our cities should never be less than 50 gallons. In fact, sanitary engineers, in determining the capacity of waterworks, generally base their calculations upon a minimum of 100 gallons per capita. Much of this amount, however, is recklessly wasted. In our garrisons, a supply of from 50 to 75 gallons is amply sufficient.

Water in Nature.

All water used by man comes from the condensation of the aqueous vapor of the atmosphere in the form of rain, snow, fog and dew. The larger proportion of this water remains on the surface as brooks, rivers, ponds, lakes and ocean. The rest percolates through the porous earth until stopped by impervious strata, at various depths.

Rain-water is the purest of natural waters. It would be more correct to say that it is the least polluted, for it is never absolutely pure, containing many of the constituents and impurities of the atmosphere. The air which it dissolves is particularly rich in oxygen (22 to 30 per cent.) and in carbon dioxid (2 to 10 per cent.). Besides coal, sand and clay dust, and various other mineral substances such as sodium chloride, calcareous salts,

etc., in almost infinitesimal proportion, rain-water contains also as constant constituents, especially in cities, ammonia (mostly as carbonate) and nitric acid, as well as a minute quantity of organic matter and a few bacteria (4 to 19 per cubic centimeter according to Miguel).

Rain-water is highly aërated, wholesome and palatable. The absence of earthy salts makes it very soft, an excellent solvent of soap, and admirably suited for washing and cooking purposes; but, for drinking water, this absence of salts is rather a defect than a quality.

Cisterns for the collection of rain-water are now seldom used at our military posts, but there are times and places when and where they may be

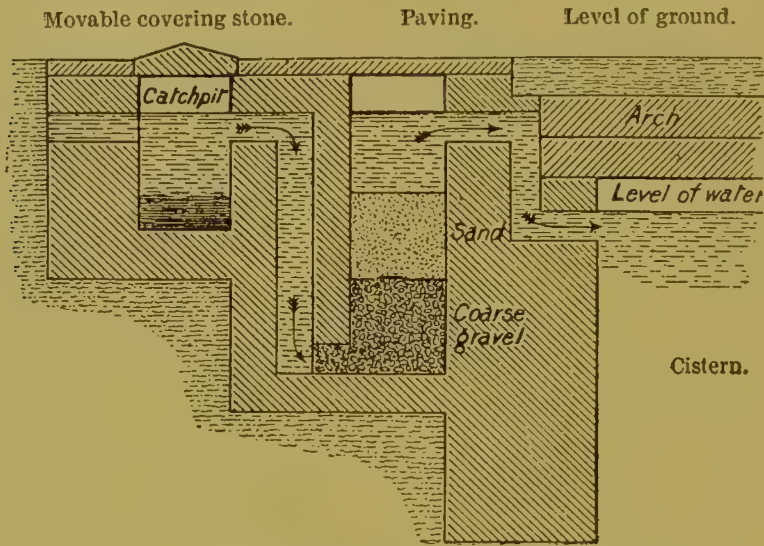

Fig. 26.—A filter for rain-water. (*Notter and Firth.*)

necessary. Of whatever material constructed, their first requirement is to be water-tight, so as to preclude leakage inward or outward. If of stone or brick, they should be thoroughly cemented; ordinary mortar will not do for the lime dissolves in water and makes it hard. If of iron, an unpleasant taste and color are imparted to the water unless covered with a protective coating. A cistern must be well ventilated but kept dark to prevent the growth of animal and vegetable life. The first portion of the rainfall, more or less contaminated by the roof surfaces, should be rejected; this is generally done by some automatic device. Should the water flow over the sloping surface of adjoining grounds, it may be advisable to pass it through a sand filter before letting it into the cistern (Fig. 26).

River-water.—River-water is of complex and variable composition, according to the character of the affluents of the river, the geological nature

of the water-shed feeding it, the number of towns and factories located on its shores and the degree of cultivation of the adjoining lands. It may be nearly as free from organic matter as rain-water or so polluted by human sewage and wastes from factories as to destroy all fish, batracians and mollusks. It always contains a large amount of matter in suspension, especially in our western and southern rivers, ranging from about 15 parts per 1,000,000 in the Hudson River at Albany, to about 1,000 parts in the Mississippi at St. Louis, and much more in the Rio Grande and Colorado.

River-water, as it flows, undergoes a very important spontaneous purification, so that at a distance of from 20 to 50 miles below a large city, the water has generally recovered the degree of organic purity that it had above it. Thus the river Seine, 25 miles below Paris, is hardly any more contaminated than above that capital. The Illinois River, some 24 miles below the points where the Chicago sewage canal empties into it, shows a bacterial content but slightly in excess of that of the local tributary streams (Jordan). This self-purification is the result of the following agencies: 1. Dilution by tributary streams, especially when their water is purer or of different temperature and composition. 2. Sedimentation, the natural effect of gravitation, whereby all organic and mineral particles tend to fall to the bottom, much more rapidly however in the quiet waters of lakes than in rivers; micro-organisms adhere to these particles and are carried down with them, hence the comparative freedom from germs of the water of our western rivers, rich in suspended sand and clay, after it has been allowed to settle. 3. Solar action, which exerts a well-marked oxidizing and destructive effect upon the organic matter and microbes of the surface and down to a depth of a few feet, according to the intensity of light and transparency of the water. 4. Biological action, probably the chief and most powerful purifying factor. Numberless animalcules, as well as aquatic cryptogams (algæ, infusoria, etc.), feed upon organic matter, but their action is slight compared to that of the usual nitrifying bacteria which decompose and mineralize animal and vegetable substances with great energy as will be explained later. This action of bacteria requires the presence of an abundant supply of oxygen and is therefore heightened by falls and rapids. Along with this oxidation and decrease of organic matter there is a corresponding fall in the number of organisms, large numbers of which are thus starved out.

Despite this self-purification, there is in the streams flowing through well-settled parts of all countries, a residuum of contamination which makes their water unsafe for drinking without undergoing some form of artificial purification.

Lake-water, compared to river-water, contains less matter in solution and suspension, nor is it so likely to become polluted, except at certain points along the shore where sewage or waste waters are discharged; but this pollution seldom extends very far in large lakes and leaves the water relatively pure half a mile or so inward.

Spring-water is water that has percolated through deep strata and which therefore is thoroughly filtered. It is cool, clear, well aërated, sparkling and palatable. It is also comparatively free from organic

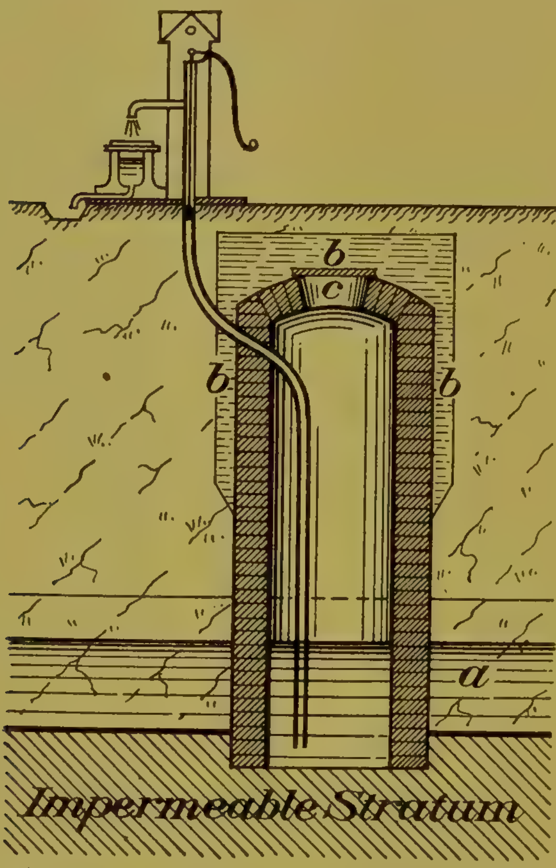

FIG. 27.—A properly constructed well; *a*, water stratum; *b*, layer of clay; *c*, manhole.

matter and absolutely so from pathogenic germs, but likely to be rich in mineral salts.

WELLS.—Ordinary dug wells are objectionable but sometimes inevitable. The deeper they are the more completely filtered and purer is the water that flows into them. Shallow wells are dangerous, being fed by surface waters and liable to be polluted by many impurities. The surface area drained by a well should be kept as clean as possible, especially from

human excreta. This area is a circle whose radius is four times the depth of the well, therefore being 400 feet all around a well 100 feet deep. It varies according to the daily fall of the water produced by pumping, widening in direct proportion to this fall.

A well, to be above suspicion, must comply with the following requirements (Fig. 27): It should traverse the entire aqueous stratum (*a*) and extend to the subjacent impervious clay or rock; it should be lined throughout, or at least above the water, with a well-constructed masonry wall vaulted at top, with manhole in center (*c*) and thoroughly cemented inside, but with enough drain holes in the aqueous stratum. The pump, instead of being placed directly over it, should be by the side of it. If there be especial danger of surface contamination, the top and outside of the wall, to half its depth or more, may be covered with a layer of well-tamped clay (*b*). Sometimes it is preferable to build the lining wall two or three feet above the surface of the ground; in such case the well must be tightly closed at top and the ground made to slope away from it.

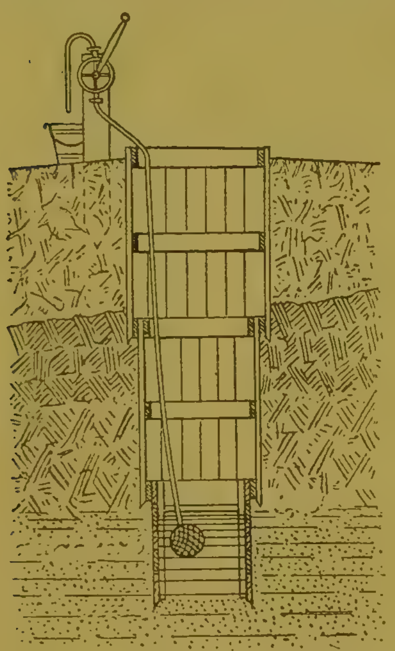

FIG. 28.—Temporary well for camps, with portable pump. (*Munson.*)

In locating a well it is important to ascertain the trend of the ground water and make sure that it is not likely to be infected. It should be above and sufficiently far away from cesspools and latrines. Even when the movement of the ground water, under a cesspool, is away from the well, there is still danger of pollution if the drainage from the cesspool, as it spreads in all directions, reaches the well before being carried off by the ground water (Fig. 29). The best and easiest test to ascertain the possibility of such infection is by the use of a strong alkaline solution of fluorescine, which, if thrown into the cesspool will, in case of leakage into the well, produce a characteristic red tint in the suspected water, recognizable to the naked eye even in a dilution of 1/100,000,000 and, by its strong fluorescence, in a still much higher dilution. Sodium chloride can be used in the same manner, and its leakage into the water ascertained by the usual silver reagent, having, first, ascertained the normal amount of chlorides in said water. For the same purpose, the culture of certain

germs has also been recommended, such as the ordinary beer yeast (Miquel) or, still better, the *bacillus prodigiosus* which is seldom found in any water, harmless and readily identified by its bright red color.

Pipe or tubular wells are greatly superior to dug wells, in all situations. The tube prevents contamination from surface waters and can be sunk until good pure water is reached, at least through the first impermeable layer of clay, so as to be entirely beyond the possibility of infection. Some of our American cities are being supplied entirely from deep tubular wells with water organically pure, and whenever a sufficient amount can thus be obtained, not containing mineral constituents in excess, it should be preferred to any that requires some form of purification.

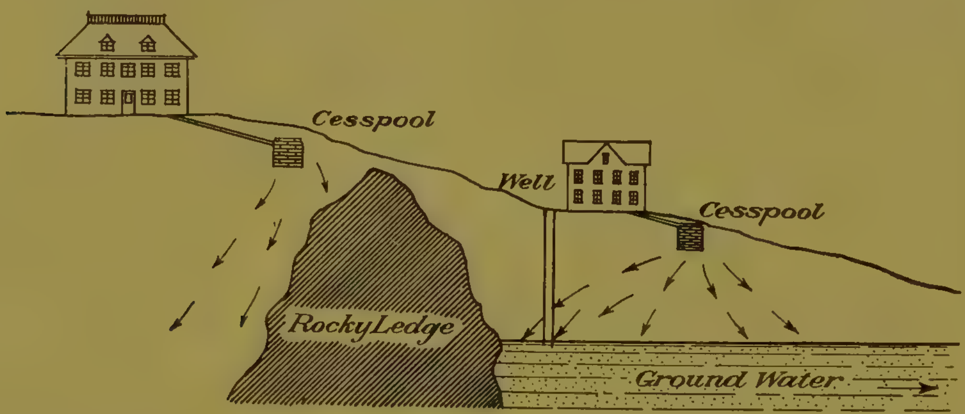

FIG. 29.—Showing how a well may be polluted from cesspool below it and protected from one above it.

EXAMINATION OF WATER.

External Qualities.—Water may be blue, green, gray, yellow or red according to its depth, matter in suspension and reflected sky, so that color (unless distinctly muddy) is not significant of its quality. It may even be dark reddish-brown as in the Dismal Swamp and many streams, the effect of the peaty beds over which it flows, or sometimes the result of a combination of the tannic acid dissolved from aquatic plants, with iron oxids. This dark-colored peaty or inky water used to be preferred by ship captains, when going on long voyages, on account of its keeping qualities. Several of our western rivers have received the name of Colorado (red) because of the color of the water seen by reflected light, due to a large amount of reddish clay in suspension.

Drinking water should be perfectly clear and transparent, but turbidity caused by mineral matters in suspension is quite compatible with good quality, after sedimentation. A bright, sparkling water may be assumed

to contain much oxygen and carbon dioxid in solution but does not contraindicate the presence of infectious organisms.

But little reliance can be placed on taste in determining the value of drinking water; it may be very palatable and yet contain dangerous bacterial life; while the taste of salt, magnesia, iron, sulphur, etc., although objectionable, does not indicate harmful constituents. Iron is detectable by taste when present to the extent of 1/5 grain to the gallon, and salt to the extent of 75 grains. The use of water with distinct taste of sodium and magnesium salts, not uncommon in the western States, is often, at first, accompanied by slight bowel trouble but, as a rule, the system soon accommodates itself to it. A water from which the gases have been more or less expelled is flat and unpalatable, as, for instance, boiled water not sufficiently aërated, but quite safe.

Water should be odorless; any smell is suspicious, especially so if of animal origin, and of a fecal or putrefactive character. Decaying vegetable matter often produces repulsive tastes and odors in the water of small, badly-screened reservoirs, rather intensified by heating. They are mostly noticed in the fall when the chilled water of the surface falls to the bottom, causing vertical currents and a stirring up of the strata. Such water, although decidedly objectionable, is probably harmless.

CHEMICAL EXAMINATION.

The chemical analysis of water, that is, the determination of its mineral and organic constituents, is essential to estimate its qualities for drinking and other purposes; but it does not give sufficient information; it tells nothing of the presence of micro-organisms, especially of the germs of infectious diseases, and must therefore be supplemented by a bacteriological examination. Both are necessary; they mutually help and complete each other.

It is not intended here to describe analytical processes, but only to indicate the mineral and organic substances usually found in water, and show their sanitary significance, that is, to what extent they may be injurious or indicative of the presence of infectious organisms.

Total Solids.—The amount of total solids in solution conveys useful information but is not of much sanitary value. Smart sets the safe maximum limit at 300 parts per million, and Wanklyn at 575, but many of our waters, particularly those of our western rivers, greatly exceed those figures without being considered harmful.

Hardness.—Water, in nature, always contains mineral salts in variable quantity, and we may assume that these salts supply some of the needs of

the body. Water containing them to a moderate extent is therefore much better than distilled water for drinking purposes. The proportion, however, should be small and the water remain "soft." Soft water, that is, water tolerably free from earthy salts, is best for all purposes, drinking, cooking, washing, steam boilers and manufactures. Water is said to be "hard" when it contains so much earthy salts that soap does not readily form a lather with it. The hardness is "temporary" or "permanent." Temporary hardness is caused by calcium and magnesium carbonates held in solution by the free carbon dioxid present in the water. Boiling expels this gas and the salts precipitate, leaving the water soft; the same result is obtained by the addition of fresh lime (Clark's process) which combines with the free CO_2. Permanent hardness is caused by calcium sulphate and other salts of calcium and magnesium, not carbonates. Boiling has but little effect upon such water; it is generally treated with sodium carbonate. When soap is used in hard water, it is at once decomposed with formation of insoluble calcium stearate, and does not begin to have any cleansing or detergent effect until all the calcium has thus been combined; hence the enormous waste of soap when used with such water.

The degree of hardness of water is readily estimated by Clark's soap test, in which a standardized soap solution is poured into a measured quantity of water until a persistent lather is formed. Permanent hardness is estimated by first boiling the water and getting rid of the carbonates.

The average hardness for American rivers, expressed in so many parts of calcium carbonate per million of water, is 50 for soft, and 150 for hard water (Leeds' standard).

The *metals* most commonly found in solution in water are lead, copper, arsenic, manganese and iron, but rarely in sufficient quantity to be obnoxious, except iron which, when exceeding the proportion of 1 part per million, renders water unsuitable for washing white goods, bleaching and dyeing; when exceeding 3 parts it is no longer fit for drinking.

ORGANIC MATTER.—The determination of organic matter in water is much more important from the sanitary point of view than that of mineral substances, for it is in it that danger lurks. It is estimated by the combustion process, that is, by evaporating a given quantity of water in a platinum dish and, after weighing, gradually raising the dish and its contents to redness and ascertaining the "loss on ignition." It is important to observe the intensity of the charring and the presence or absence of fumes; the latter, if present, may indicate the character or source of the organic matter. Water of high organic purity should give no appreci-

able blackening nor odor. According to Smart: "The blackening during the process is of more interest than the mere loss of weight. No matter how few parts are lost, if the lining of the capsule blackens all over and the carbon is afterward dissipated with difficulty, the water is to be viewed as suspicious. What are called "peaty" waters here constitute the exception."

Another method of estimating organic matter is by determining the amount of "required oxygen" to oxidize it. It consists in the addition of a solution of potassium permanganate of known strength to a measured amount of water acidified with sulphuric acid and heated to the boiling point, until the red color persists. The amount of oxygen required, in good waters, should not exceed two or three milligrams to a million milligrams (1 kilo) of water.

A pretty constant relation has been noticed between the "required oxygen" and the carbon of organic matter, the latter being obtained by multiplying the former by 2.50 or 3. Again, the proportion of carbon to nitrogen affords evidence as to the origin of the organic matter; a ratio of 3 to 1, or less, would indicate animal matter, while if as high as 8 to 1, matter chiefly or entirely of vegetable origin.

Carbon is a constituent of every living tissue, but, from the sanitary chemist's point of view, of little importance.

It is from nitrogenous organic matter (nearly always from animal sources) that we obtain our most useful information; of its constituents, four are of especial significance, namely: chlorine, ammonia, nitrites and nitrates.

Chlorine is almost invariably found in water, generally as sodium chloride (common salt) washed from the air or soil, or added from cesspools. Salt, of itself, is harmless but, when in excess, shows probable sewage contamination. Ordinary sewage contains from 110 to 160 parts per million of chlorine which comes almost entirely from the urine, the solid excrement containing but a minute proportion. Before estimating the significance of chlorine it is necessary to know the normal amount found in the waters of the region, for this is very much influenced by the proximity of the sea and the existence of local salt strata. Leeds' standard for American rivers is from 3 to 10. Frankland places the permissible limit at 50.

Ammonia exists in water as free ammonia and albuminoid ammonia. Free ammonia, either really free or as an ammonium salt, passes over unchanged with the steam when the water is distilled. Albuminoid ammonia does not exist ready formed but is a product of the decomposi-

tion of organic nitrogenous substances by the action of potassium permanganate. Rain-water, especially when collected near large cities, often contains a large proportion of free ammonia, while river-water seldom shows more than traces of it. As water filters through the porous earth, its ammonia is rapidly converted into nitrites and nitrates, so that the presence of this gas in any considerable quantity in shallow wells indicates probable recent contamination with animal matter. Growing plants have a marked influence in reducing free ammonia; thus a lake which contains as much as 0.57 in January may not show any at all in August (Drown). A high proportion of ammonia, without animal contamination, is likely to be found in waters from ferruginous swampy regions, owing to the action of iron oxids upon organic matter. Likewise, much free ammonia may exist in deep-well waters of excellent quality, due to the reduction of nitrates and nitrites by sulphide of iron or other agent, such nitrogen salts being the result of oxidation in past ages, and in nowise indicative of pollution (C. B. Fox). In testing for ammonia, the rate at which it is evolved, according to Smart, is as important as the total amount: "Gradual evolution of albuminoid ammonia indicates the presence of organic matter, whether of vegetable or animal origin, in a fresh or comparatively fresh condition, while rapid evolution indicates that the organic matter is in a putrescent or decomposing condition."

According to Wanklyn, water containing over 0.15 of albuminoid ammonia should be condemned; but Mason thinks that many waters, especially brown peaty waters, of proved wholesomeness, may far exceed this proportion. The following maximum limits are proposed by Leeds:

Free ammonia	.01 to .12 per million.
Albuminoid ammonia	.10 to .28 per million.

An excess of free ammonia over albuminoid ammonia, indicating an active process of decomposition, is always a suspicious sign, unless both numbers be low.

Nitrites result from the oxidation of the ammonia of organic matter, the second step in the process of nitrification, or may likewise be due to the reduction of preexisting nitrates. Being transition products, their presence in ground or surface waters is usually evidence of active fermentative changes and, even in the slightest proportion, should always be looked upon with suspicion. In spring and deep-well water, Frankland has shown that they are without significance, being generated by the deoxidation of nitrates "brought about either by the action of reducing mineral substances, such as ferrous oxid, or by that of organic

matter which has been imbedded for ages or, if dissolved in water, subjected to exhaustive filtration." The absence of nitrites proves nothing; it may be due to lack of available oxygen and does not show the absence of dangerous organic matter. Leeds' standard for American rivers is 0.003. Good water, unless from deep well, should not exceed 0.01.

Nitrates represent the completed process of the oxidation of nitrogenous organic matter, the process of nitrification; they are the ashes of organic matter and therefore simply indicate contamination at some previous time. This contamination is more likely to be of animal than of vegetable origin, not only because of the greater quantity of nitrogen present in animal matter but also on account of its more ready decomposition. Nitrates form very slowly in rivers, animal matter being much less actively oxidized in running water, especially if deficient in dissolved oxygen, than in water percolating through the soil, and are, besides, constantly deoxidized by the addition of fresh organic pollution. A marked departure, either by increase or decrease, from the usual proportion of nitrates in any water may be taken as evidence of contamination. There are two natural sources of nitrogen which should be considered in estimating the normal proportion of nitrates in the water of any region: the first is washed from the atmosphere as nitric acid and amounts from 0.15 to 0.40; the second is washed from soils in which certain leguminous plants are cultivated (alfalfa, clover, cow-pea, etc.) and where it is stored by various kinds of bacteria which abstract it from the air.

Leeds' standard for American rivers is 1.11 to 3.89. Good surface water should not exceed 1 or 2 parts. Spring or deep-well water may contain a much larger amount without significance, having dissolved it while filtering through various strata or from old beds of organic matter entirely free from organisms.

MICROSCOPIC AND BACTERIOLOGICAL EXAMINATION.

Water contains many forms of low cryptogamic life, such as fungi, algæ, desmids, diatoms, sponges, infusoria, etc., which have but little effect upon its sanitary value, except in occasionally producing very disagreeable odors. Some branching forms of minute fungi (cladothrix, crenothrix and beggiatoa) multiply rapidly and may clog pipes and drains or sometimes become objectionable on account of the large amount of iron which they absorb. Water may also contain the eggs of intestinal parasites such as ascaris, oxyurus, trichocephalus, tænia, ankylostomum, etc. It ordinarily abounds with many forms of bacteria, nearly all of which are saprophytic and probably more beneficial than harmful.

Some of them, however, have been accused, by causing putrid fermentation, of increasing the virulence of pathogenic germs.

According to Leon Gérard (of Brussels), a properly conducted microscopic examination may afford much useful information concerning the organic impurities of water. For this purpose, the water is passed successively through four wire screens, each with meshes finer than the preceding (from 500 to 5,300 meshes per square centimeter), the last screen consisting of two thicknesses of wire cloth with white filtering paper between. The sediments on each screen are then examined with magnifying lens and microscope. Contamination by man and animals is indicated by four classes of substances: 1. Fragments of textile fabrics; fibers of wool, cotton, linen, silk; hairs of man and animals; sections of human hairs cut in shaving, in the shape of flat, oval or roundish disks, sometimes extremely thin and remarkably well preserved. 2. Grains of starch (cereals, potatoes, etc.) which reveal pollution from kitchen wastes. 3. Débris of muscular fragments, easily recognized by their structure and certain microchemical reactions; such débris indicating almost certainly fecal pollution. 4. Eggs of intestinal parasites, which also prove contamination by the fecal matter of man or animals.

The usual and principal object of the bacteriological examination is to ascertain whether or not the water contains pathogenic organisms, or the organisms which are usually associated with them and reveal the presence of contamination, whether from sewage, manure, or other source. The total number of bacteria contained in a cubic centimeter of water gives us doubtless more or less knowledge of the nature and extent of the contamination; it is mostly valuable, however, in ascertaining the degree of efficiency of filtration; thus a properly constructed and well-conducted filter should yield water containing less than 100 bacteria to the cubic centimeter, that is to say, water producing less than that number of colonies when sown on nutrient gelatine and kept in a temperature of 20° C. for four days. In unfiltered water, the number varies enormously; but in really good water it should not usually exceed 1,000, while in merely passable water it ranges from 1,000 to 10,000, and in bad water exceeds 10,000. Spring-water and deep-well water are most free from bacteria; lake-water comes next in purity, especially at some distance from the shore, while river-water is the worst. The Lake of Geneva was found to contain 150,000 bacteria to the c.c. near the shore and only 38 in the middle (Fol et Dunant); the river Seine, above Paris, from 46,340 in December to 13,710 in August; the Thames (in 1886) from 45,000 in January to about 3,000 in July. It is noticed that, in temperate regions,

the number falls considerably in summer when rains are few and shorter, while in winter the more continuous rains and many small streams from melting snow carry with them a much larger amount of soil pollution.

The degree to which a river can be infected by the sewage of a large city is illustrated by the Spree which shows only 8,951 bacteria above Berlin and 343,000 two miles below it.

The most usual and dangerous pathogenic organisms present in water are those concerned in the etiology of typhoid fever (*bacillus typhosus*), cholera (*comma bacillus* or *cholera vibrio*) and dysentery (*bacillus dysenteriæ* of Shiga, and *amœbæ*). Unfortunately they are very difficult of detection in water, on account of their comparative rarity, and their presence can only be assumed by the recognition of other and more common intestinal organisms, more or less harmless to man but plainly indicative of fecal pollution. These witness bacteria ("bacterial indicators"), readily found and recognized in water, are always present in the intestinal discharges of man and other mammals, and, therefore, in sewage and manure. They are:

1. *Bacillus coli communis*, or colon bacillus. The best indicator of dangerous contamination. Common everywhere from the excrements of man, mammals and birds. Under favorable conditions it is capable of multiplying outside the body so that it may become a constituent of road dust, likely to be blown into reservoirs and even cisterns, but this mode of pollution seldom exceeds a few bacteria to the cubic centimeter. There is no evidence that the true type of this bacillus is ever present in any large number in rivers which have not been exposed to fecal contamination. Under ordinary conditions it does not multiply in water supplies, unless they contain fecal matter. Although its vitality outside the body is not great, it is more resistant than the bacillus typhosus, so that, if absent, it is nearly certain that the latter is also absent.

As it is not possible to differentiate the human colon bacillus from that of animals, a careful study should be made of all the factors involved so as to determine, if possible, the source of contamination; for instance, whether from the excrements of pasturing animals or from latrines.

The colon bacillus includes a number of forms differing in characters and reactions and often hard to separate. The typical form is the only one that has much significance. It is identified by the following characteristics: fermentation of glucose or lactose broth with rapid gas production, most or the whole of it being evolved in twenty-four hours, the total amount approximating about fifty per cent. and consisting of H and CO_2 in the proportion of 2 to 1; liquid in bulb of fermentation tube

strongly acid; a distinct indol reaction; coagulation of milk in 1 to 3 days; growth on gelatine in the form of non-liquefying, opaque, whitish expansions with irregular margin.

2. *Streptococci*, under several forms, are abundant in human and animal excreta and therefore in sewage. They are naturally parasitic, delicate germs, unable to multiply and rapidly dying outside the animal body, although some persistent forms are met with. They seldom live more than a week or two in water; their detection in any quantity, therefore, shows recent fecal pollution, and therein lies their chief value as bacterial indicator.

3. *Bacillus enteritidis sporogenes* (Klein), probably identical with *B. aërogenes capsulatus* of Welch, is also abundant in human and animal excreta, but its usefulness as an indicator is very much limited by the fact that the spores only can be used for its detection, not the bacillus itself. As these spores are highly resistant and may persist for long periods, their presence simply indicates pollution at some indefinite time in the past (perhaps weeks or months before) and which may have long ceased to exist. Therefore, of themselves, they are without significance, but when found with the colon bacillus add confirmation to the evidence yielded by that organism.

Closely allied in appearance and reactions, and frequently found with B. enteritidis, are *B. butyricus* and *B. cadaveris sporogenes* which are likewise indicative of pollution.

CHAPTER XIII.

WATER PURIFICATION.

Water, to be pure, or at least potable and safe, must be ridden of its obnoxious constituents, especially its organic matter and micro-organisms.

The three general methods of purification are by heat, chemical means and filtration.

For an army in the field, the ideal method of purification is one that can be carried out in all situations, with a small, simple, transportable outfit yielding plenty of good, cool, palatable water within a short time. Thus a regiment of 1,800 men should have at least 400 gallons of purified water within two hours after going into camp. However strict the discipline, it will always be very difficult to prevent men, when impelled by thirst, to drink from condemned sources if good water is not promptly available.

HEAT.

Heat is the most certain and effective of purifying agents and the only means of obtaining an absolutely sterile water. Boiling destroys all pathogenic germs; it also removes the temporary hardness of water by precipitating the carbonates. It does not decompose organic matter, nor destroy its odor or color, but renders it less putrescible. An objection to boiling drinking water is that its gases are driven out, leaving it flat and unpalatable. But boiling is not necessary for the practical sterilization of water. A temperature of 165° F., maintained for ten minutes, is sufficient for the destruction of all ordinary pathogenic bacteria; thus less fuel and time are required; less gas is lost and the more rapidly is the water cooled down. Water purified by boiling should always be thoroughly aërated after cooling, by dipping and pouring from a height, decanting from one kettle to another or blowing air directly into it.

In the field, the camp fire can generally be resorted to, in the absence of special apparatus, provided suitable kettles are available. The water should be sterilized in the evening, properly aërated and the canteens filled directly afterward so that it may be quite cold in the morning. This primitive method of sterilization, although often necessary, is seldom satisfactory.

THE FORBES STERILIZER.

This sterilizer (Fig. 30) was officially adopted in the Army after competitive tests by a special board in 1898. Fig. 31, which is merely diagrammatic, illustrates the principle of its operation.

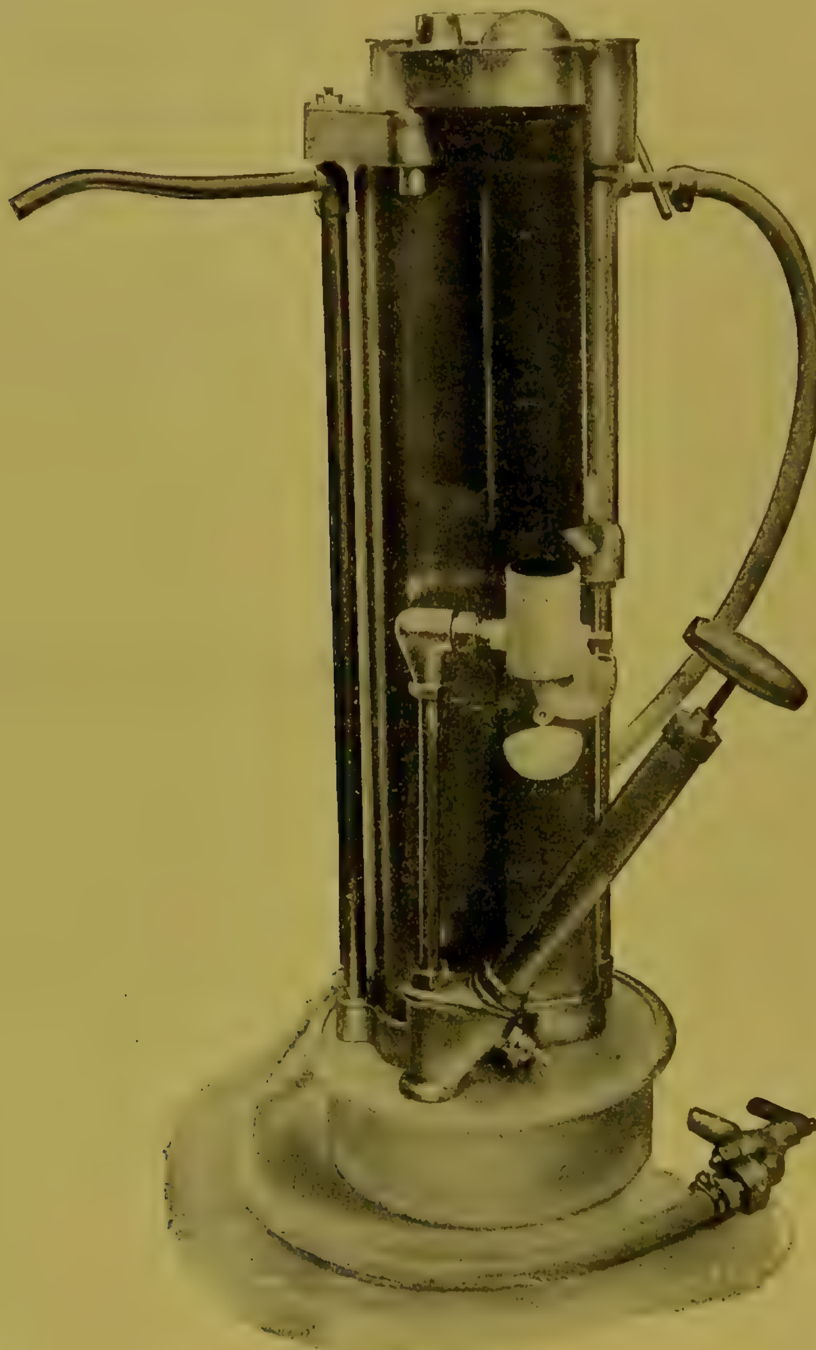

FIG. 30.—Forbes sterilizer ready for operation.

Raw water enters at 1 and passing through the open valve 7 flows down through the tube 2 and enters the lower end of the raw water compartment 3 of the "heat exchange." Rising in the compartment 3, the water, which is shown by light shading, fills the compartment and enters the float-box 4. Passing from the float-box 4, the water enters and fills

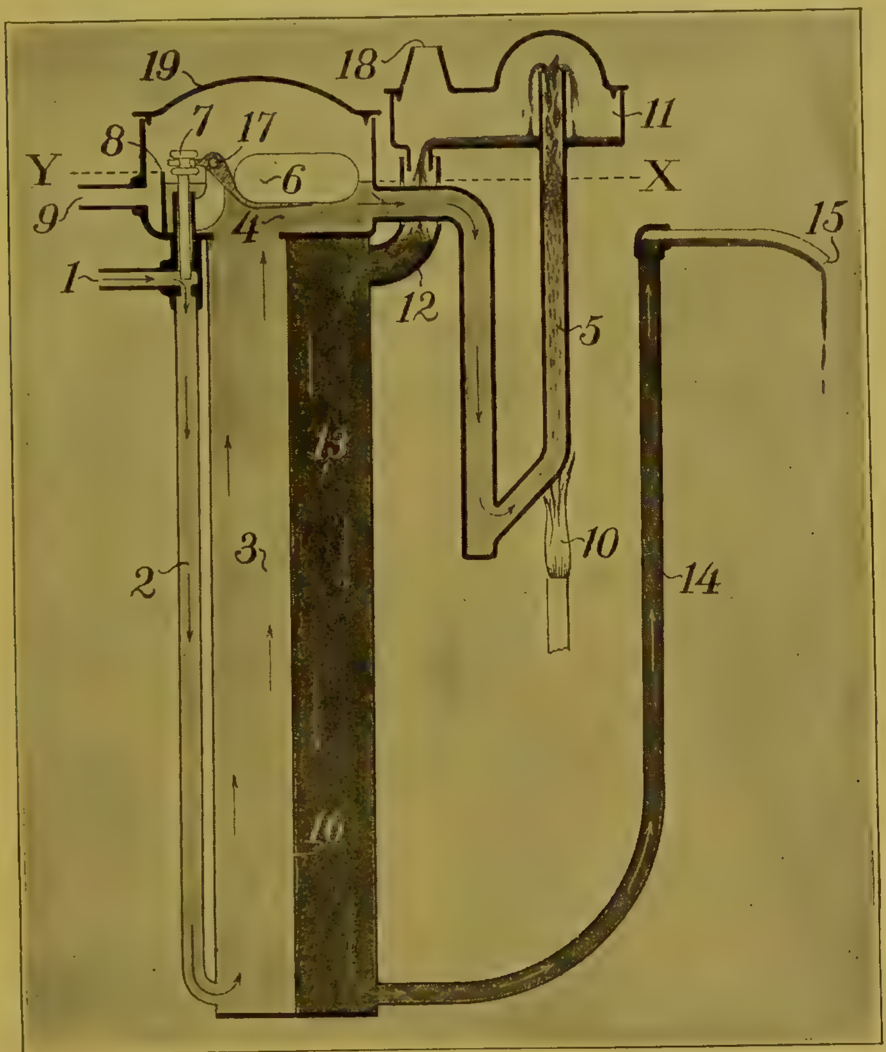

FIG. 31.—Schematic diagram of the Forbes sterilizer.

the heater 5 up to the level X. The water in the float-box 4 must also be at the same level X and at this point the water lifts the float 6 and closes the valve 7, thereby preventing more water entering the apparatus at 1.

Should the float or valve stick or fail to rise through any cause, the water will continue to rise in the float-box 4 and likewise in the heater 5

until it reaches the level Y, where it will overflow at 8 and pass through the pipe 9 to waste. Higher than this level Y the water cannot go.

Heat, in the shape of flame 10, is applied under the heater 5, thereby causing the water in 5 to boil, and in boiling it will rise in the tube and overflow at the top into the catch-all 11. From the catch-all 11 the hot sterile water, represented by dark shading, flows down through 12 into the sterile water compartment 13 of the "heat exchange." The pipe 14 conveys the sterile water up to the discharge 15. This outlet 15 is brought to the top of the "heat exchange" to insure the sterile water compartment 13 always being full of water. While passing down through the sterile water compartment 13, the heat of the water is absorbed by the cold water rising through the raw water compartment 3, and the transfer of the heat from the hot to the cold water takes place through the thin metal diaphragm 16; so that the water leaves the apparatus cold, having given up its heat to the cold water entering while, on the other hand, the cold water entering the apparatus, having absorbed the heat of the hot water leaving the apparatus, enters the float-box 4 and heater 5 very hot and nearly at the boiling point. Only a small amount of heat is, therefore, necessary to keep the sterilizer in continuous operation.

The heating apparatus consists of the oil reservoir, air pump and the burner proper. This is the most important feature of the sterilizer and its construction and management must be thoroughly understood and mastered by the operator if good results are desired. Fig. 32 illustrates the principle of operation of the burner. 1 represents the vaporizing tube into which kerosene-oil is fed under pressure. As the oil K passes along the tube in the direction shown by the arrow, it is turned into vapor V by coming in contact with the hot inside surface of the vaporizing tube 1. This vapor V being under the same pressure as the oil K (about 45 pounds per square inch) issues downwardly from the small hole in the nipple 2, in a swift jet J and enters the upper end of the curved mixing tube 3. This jet J is so formed that in entering the mixing tube 3, it induces some air to enter the tube with it as indicated by the arrows A A. While passing through the mixing tube 3, the vapor and air become mixed and form a partially combustible gas P. On issuing from the mixing tube 3, this partially combustible gas P rushes upward in a jet into the burner shell 4 and acting similarly to the jet J, it induces more air, as indicated by the arrows B B, to enter the burner shell with it, thereby making a highly combustible gas G. The gas G bursts into flame F after entering the burner shell 4 a short distance, and bathes the vaporizing tube 1 with an

intense heat, thereby maintaining a continuous vaporization of the oil and becoming a self-supporting operation.

The Forbes sterilizer, packed in its field case of galvanized steel, is 37 inches high and 11 1/2 inches in diameter, and weighs 96 pounds. It burns one quart of oil in three hours, and averages an output of 15 to 20 gallons of sterile water an hour.

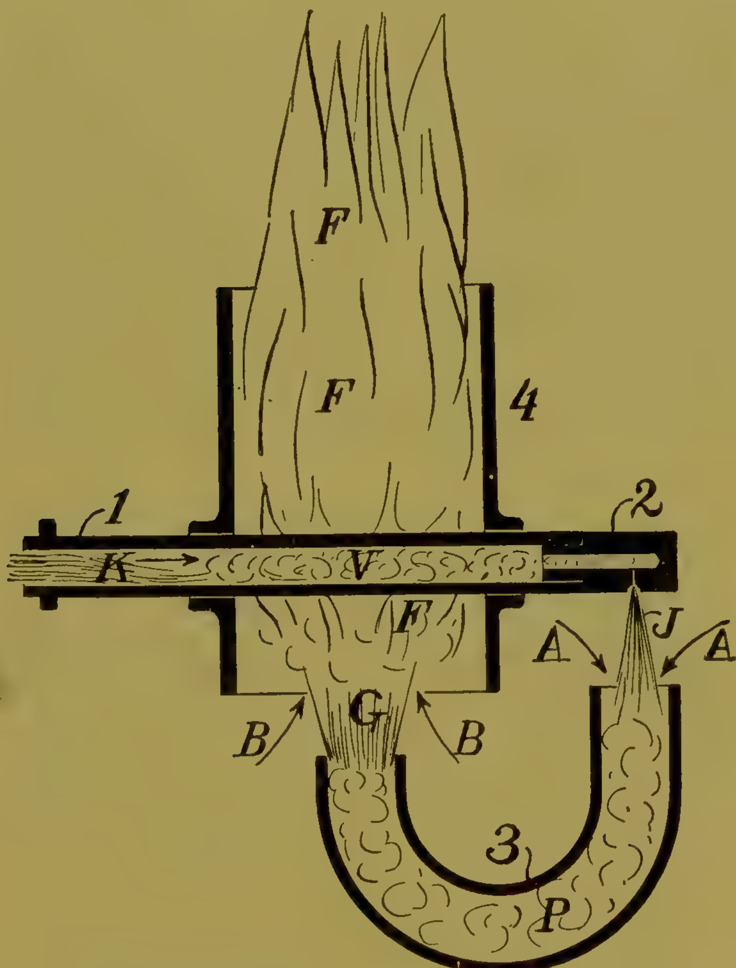

FIG. 32.—Schematic diagram of the oil burner of the Forbes sterilizer.

As in every other form of sterilizer, the water remaining in the apparatus, when not in use, becomes rapidly contaminated with the ordinary saprophytic bacteria, and on that account it is advisable, when again started, to reject the output of the first half hour.

This sterilizer, when properly operated, is entirely reliable and has rendered excellent service in many of our camps and garrisons. Its advantages may be stated as follows:

1. The water is not deprived of its natural gases.

2. All living micro-organisms are destroyed, except a few harmless spore-bearing bacteria.

3. It may be kept in action for 24 hours without renewing the supply of oil in the reservoir.

4. The water flows out of the apparatus only 4 1/2° F. warmer than when it entered it.

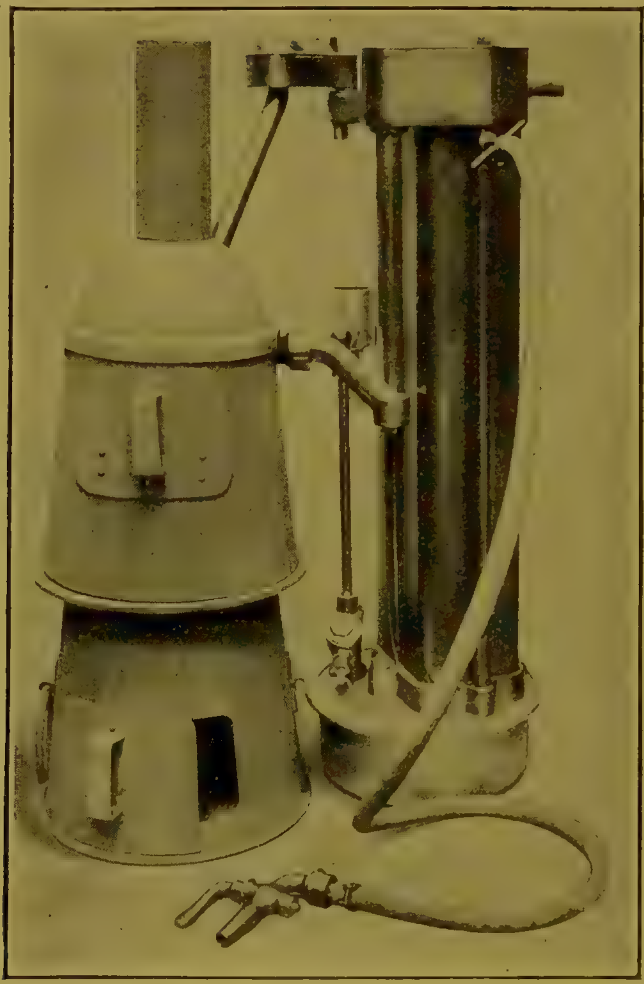

FIG 33.—Wood-burning attachment connected to the Forbes sterilizer.

5. It is easily taken apart, cleansed and put together again.

6. It is durable, not liable to breakage and very easily transported.

Besides the usual form above described, for burning mineral oil, there is another with fire-box attachment for burning wood or coal (Fig. 33). There is also a "barrel accessory" (Fig. 34) consisting of two barrels, a

large one for raw water, elevated on a steel stand, supplying the sterilizer through a rubber tube, and a smaller one into which the sterile water is discharged.

WHEELED STERILIZERS.—For field purposes, however, a sterilizer to be entirely satisfactory should be mounted on wheels and able to follow a moving command, consume either wood or coal, yield a sufficient daily output for at least a regiment and always have a reserve of available cool

FIG. 34.—Barrel accessory set up, ready for operation in connection with the Forbes sterilizer.

water in its tank. Such are the German Henneberg Trinkwasser (Fig. 35) and the French Vaillard-Desmaroux outfits, in which the water is raised, under pressure, to a temperature of 240° F. without boiling, so that it is rendered absolutely sterile without the loss of any air. These types are open to the objection that the absolute sterility which they produce is not required, therefore that they consume more fuel than is necessary and deliver a water relatively hot. An apparatus meeting the requirements in a more satisfactory way, has also been recently constructed by the Forbes

Co. Their "Army wagon sterilizer" consists of boiler, pumps, filter, sterilizer and storage tank mounted on regulation army wheels (Fig. 36). It filters and sterilizes 300 gallons of water per hour, and 14 men may draw their supply at the same time from its 150-gallon storage tank. The same principle of heat exchange is applied as in the smaller sterilizer so that the water runs out only a few degrees warmer than when pumped in. The complete outfit weighs, empty, 3,500 pounds and, when full, 5,200 pounds.

FIG. 35.—The German Henneberg Trinkwasser wagon.

GRIFFITH STERILIZER.—In England, the Griffith sterilizer is highly spoken of and, apparently, well adapted to military purposes. It consists essentially of a heater and a cooler. The heat is obtained from a lamp burning coal oil under pressure. As soon as the water reaches the temperature of 180° F., which is sufficient to destroy all disease-bearing organisms, a valve opens automatically, by expansion, and allows it to flow into the cooler. A larger type, mounted on wheels, gives 350 gallons of water an hour and has a storage tank for 50 gallons. It consumes 1 gallon of oil to sterilize 480 gallons of water.

Disadvantages of Sterilizers.—Several objections may be raised against heat sterilizers. They are costly and heavy. The fuel, whether it be oil,

coal or wood, will often be difficult to procure and transport in sufficient quantity. The yield of the ordinary Forbes sterilizer is relatively small, seldom exceeding 15 gallons an hour, so that quite a number are required to supply a regiment. This objection does not apply to the large wheeled outfit, but this, on the other hand, is open to the serious criticism that it must remain on the road, perhaps unable to follow the regiment when most needed, and that, in any case, it cannot supply detached battalions and companies. It seems to be more especially adapted to the needs of

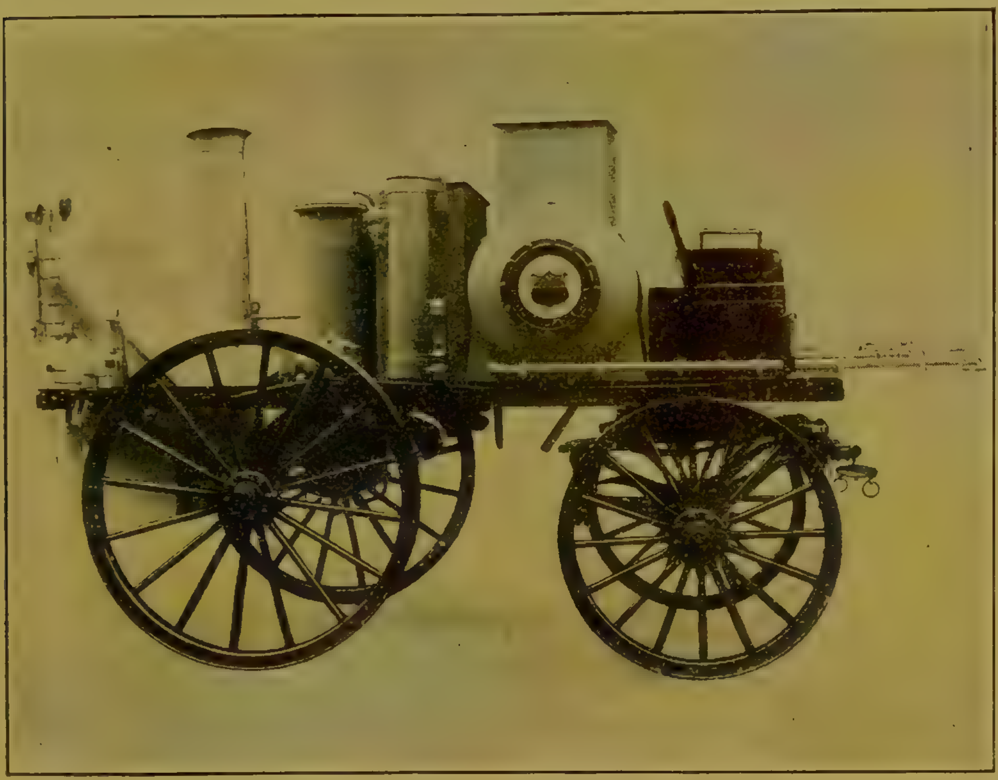

FIG. 36.—The Forbes Army-wagon sterilizer

permanent or semi-permanent camps. All sterilizers, particularly the large types, are more or less complicated and require careful and intelligent management. Their efficiency is also very much impaired by water containing much carbonate of lime which soon incrusts the partitions or tubes of the heat exchange, as well as the boiler, and lessens the output.

DISTILLED WATER.—Distilled water is necessarily pure and sterile, but the absence of mineral matters and scarcity of gases in solution render it somewhat insipid and less fitted to the needs of the body than good natural water.

COLD.—The purifying action of cold also deserves to be noted. Water in freezing forces out, into the subjacent layer, most of its matters in solution but only a part of those held in suspension, retaining most of its organic matter and bacteria, especially when much air is imprisoned as in snow or porous ice. Therefore, clear ice is purer than snowy ice, and top ice (if clear) than deep ice. The first effect of congelation, according to C. Frankel, is the death of the greater part of the micro-organisms; four-fifths disappear in two days and nine-tenths in five days. The pathogenic bacteria, however, are among those most resistant to cold; when subjected to a freezing temperature the cholera bacillus succumbs in seven days, but the anthrax bacillus may persist for weeks and the typhoid bacillus for several months. It is also of common notoriety that the larvæ of mosquitoes may remain in ice all winter in a quiescent state and, in the following spring, develop into full-fledged insects. We may then conclude that ice is safer than the raw water beneath, especially if from a deep, calm pond or lake, but that it is not always safe, that it may contain thousands of microbes and has been the means of transmission of typhoid fever. Therefore, unless it is known to be reasonably pure, it should not be used in water nor placed in contact with articles of food. Artificial ice, if made from distilled water, as it always should be, is entirely above suspicion and should always be preferred.

CHEMICAL MEANS.

Chemical agents purify water by the oxidation of its organic matter and microbes, or by the precipitation of its matters in suspension. The use of these agents is attended with many difficulties and seldom practicable in the field. The proportion of chemicals must be adjusted to the character and impurities of the water, rendering a careful and variable dosage necessary. They often require a partial removal of organic matter before their use, and as they may produce precipitates or turbidity, clarification afterward. Moreover, foreign substances are introduced into the water, often imparting an unpleasant taste to it, and the effect of which upon the body economy has to be considered.

Ozone.—The best chemical method of purification, so far devised, is undoubtedly that by ozone, based upon the powerful oxidizing effect of ozonized air upon organic matter and micro-organisms. First introduced by Ohlmüller and recently perfected by Siemens and Halske, this method has already given very remarkable results, under favorable conditions absolutely eliminating both organic matter and bacteria from the water. The ozone is generated by a special apparatus and, after being mixed

with a current of dry air, forced up a cylinder containing gravel and down which the raw water percolates. It imparts no unpalatable or harmful element to the water. It first oxidizes the organic matter, and afterward the more resistant bacteria; the amount therefore must vary with the proportion of organic matter and demands a nice adjustment at the hands of a skilled operator. Turbid water generally requires a preliminary filtration.

The entire outfit has also been mounted on wheels with the object of making it available for troops in the field, but it is not well adapted to that purpose on account of its complexity, the expert manipulation required and the variable composition of the waters to be purified.

The other chemicals recommended at various times for the purification of water include bromine, iodine, chlorine, potassium permanganate and copper.

Bromine, according to the Shumburg method, is used in a solution of potassium bromide (20 grms. each of bromine and potassium bromide in 100 cubic centimeters of water). About two cubic centimeters are sufficient for one quart of ordinary raw water; at the end of 15 or 20 minutes the excess of bromine is neutralized with ammonia or sodium hyposulphite. A large proportion of microbes are destroyed but many escape; furthermore, the transportation and handling of bromine and other chemicals in solution are inconvenient and often impracticable in the field.

Iodine, as recommended by Vaillard, is less objectionable as only tablets are used. Three kinds are required: No. 1 (blue), containing potassium iodide and sodium iodate; No. 2 (red), of tartaric acid; No. 3 (white), of sodium hyposulphite. If one blue and one red tablets be crushed and dissolved in a little water, a brown fluid containing 0.06 grain of nascent iodine results; this, if added to a liter of water, will destroy its micro-organisms in ten minutes. Tablet No. 3 may then be added to neutralize the excess. This is a neat and efficient process, somewhat complex for general use by the men but well adapted to the needs of officers.

Chlorine, in the form of chlorinated lime (mixture of calcium chloride and hypochlorite) or of chlorinated soda (sodium hypochlorite), is effective if used in sufficient quantity, but is liable to produce turbidity in the water and the excess must be neutralized by sodium hyposulphite. It also imparts an unpleasant taste to the water.

Potassium permanganate has long been used as a water purifier and yields fairly good results. A sufficient quantity must be added to the

water to impart a faint pink tinge which should persist for half an hour. From 5 to 10 centigrams to a liter (about a grain to the quart) is required in average water to oxidize and destroy the organic matter and bacteria, but its action is very slow and somewhat uncertain. Vaillard, however, declares that in water previously clarified, 2 to 4 centigrams to a liter will destroy, in 30 to 40 minutes, all pathogenic and sporeless bacteria. After using permanganate it is well to filter the water to get rid of the brownish precipitate of manganese oxide, although probably innocuous. The water generally retains an unpleasant taste.

Copper sulphate has been highly recommended as a germicide and algicide. In the proportion of 1 to 1,000,000–10,000,000, it will destroy most of the algæ which often infest reservoirs and drains. If evenly distributed and the water is filtered afterward it can safely be used in the above proportions in drinking water. It cannot be depended upon to destroy all micro-organisms except in dangerous doses (1/50,000 to 1/100,000).

Those chemical agents which act as coagulants and precipitate matters in suspension will be considered under filtration.

FILTRATION.

Filtration is the method of purifying water in which we seek to imitate the natural percolation taking place in nature, through the superficial porous strata of the earth, whereby contaminated surface water is transformed into the pure water of springs and deep wells.

Filtration is chiefly a mechanical process; that is to say, the action of a filter is mainly that of a very fine strainer and therefore limited to the suspended or insoluble matters of the raw water. We may, therefore, expect to see the turbidity, sediment and bacteria largely or entirely disappear, while organic matter and other substances in solution, such as those producing hardness, color and smell are removed only to a slight extent, if at all. Besides this mechanical action, however, we also often find the evidences of a biological action in filters, varying in degree according to the method pursued. We know that bacteria are more minute than the pores of a Berkefeld or Chamberland filter, or the spaces between grains of fine sand; if they do not pass through with the water, it is because of a molecular attraction whereby they adhere to the grains of sand or the walls of the pores, an adhesion aided and strengthened by the viscous organic matter found in most waters and which lines the pores, or covers the grains of sand of filters. Thus arrested, the bacteria are subjected to unfavorable conditions which soon bring about their oxidation and de-

struction. It readily happens, however, that if certain precautions are neglected, the bacteria find suitable conditions for their multiplication and gradually extend, by growth, through the filter into the filtered water which thus may become worse polluted than the raw water. Therefore, although filtration when properly carried out is a very efficient means of purification, it may also, when carelessly conducted, be the source of serious contamination.

Whenever coagulants are used, previous to filtration, there is a chemical action added to the mechanical and biological actions. In quick mechanical filtration, there is no time for any biological action to take place, the organic matter and bacteria being simply removed instead of being oxidized.

Domestic Filters.

Of these filters the number is legion. The best-known types and the most effective, like the Pasteur-Chamberland and Berkefeld, consist of

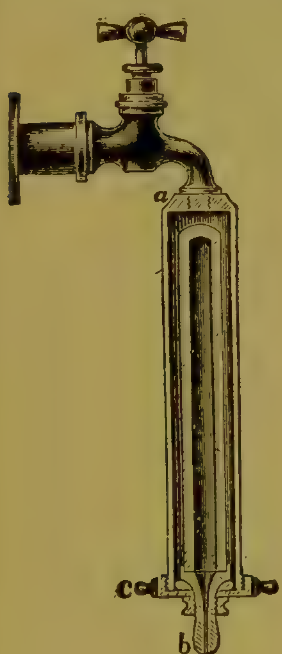

FIG. 37.—Section of Berkefeld filter. (*Munson.*)

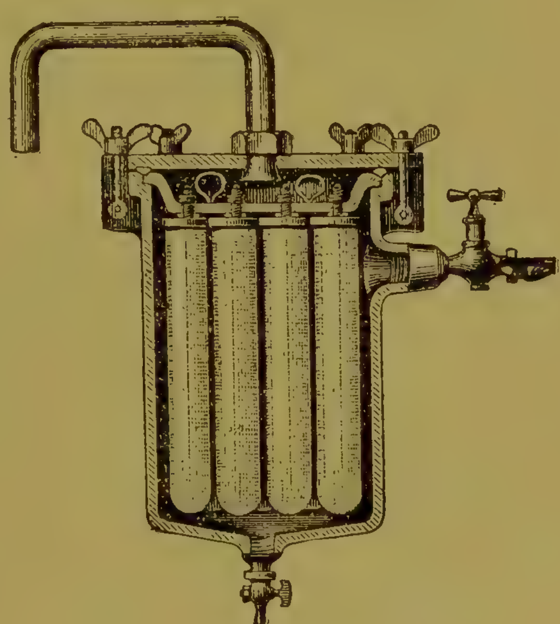

FIG. 38.—Battrey of Berkefeld filters. (*Munson.*)

unglazed porcelain cylinders made from a mixture of kaolin and other special clays. The Berkefeld filter was also formerly made of infusorial earth (microscopic skeletons of diatoms). Finely powdered asbestos is sometimes added to the clay as in the Mallié or Porcelain-Adamant

filter. They are mostly in the form of hollow cylinders called "candles" or "bougies" closed at one end and open at the other or nipple-shaped end (Fig. 37). Each bougie is inclosed in a glass or metal jacket with an intervening space between. The head of the jacket being screwed to a water tap, the raw water enters into the space surrounding the bougie and, passing through its walls into the hollow interior, discharges at the

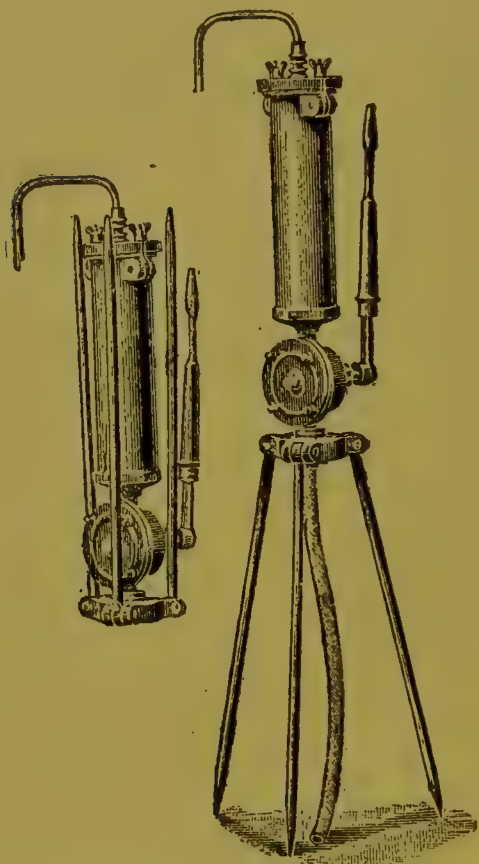

FIG. 39.—Berkefeld filter with pump for field use (*Munson.*)

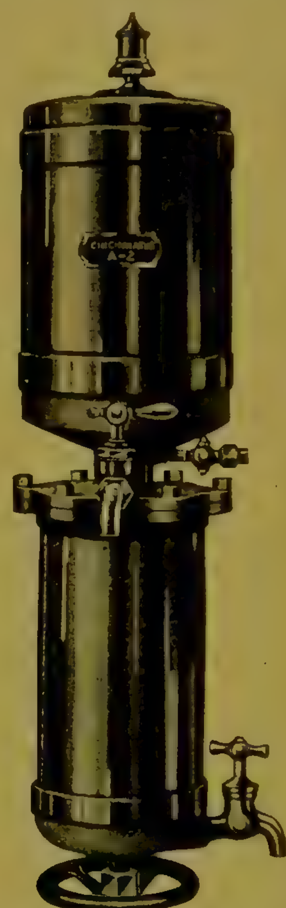

FIG. 40.—Cincinnatus filter with scraping device controlled by wheel at bottom, and reservoir above.

nipple end. For proper functioning the pressure should be at least equal to one atmosphere. These cylinders can be set together and operated in batteries (Fig. 38). In the field such batteries are supplied with a hand-pump attachment (Fig. 39). The output is small, seldom exceeding five quarts an hour per cylinder, being somewhat larger with the Berkefeld than with any of the others.

All these filters not only clarify but are also capable of purifying the

water. When put in operation, after sterilization, the Chamberland and Berkefeld furnish at first a water absolutely sterile. But it is noticed that the output decreases rapidly, falling from 4 to 5 quarts an hour

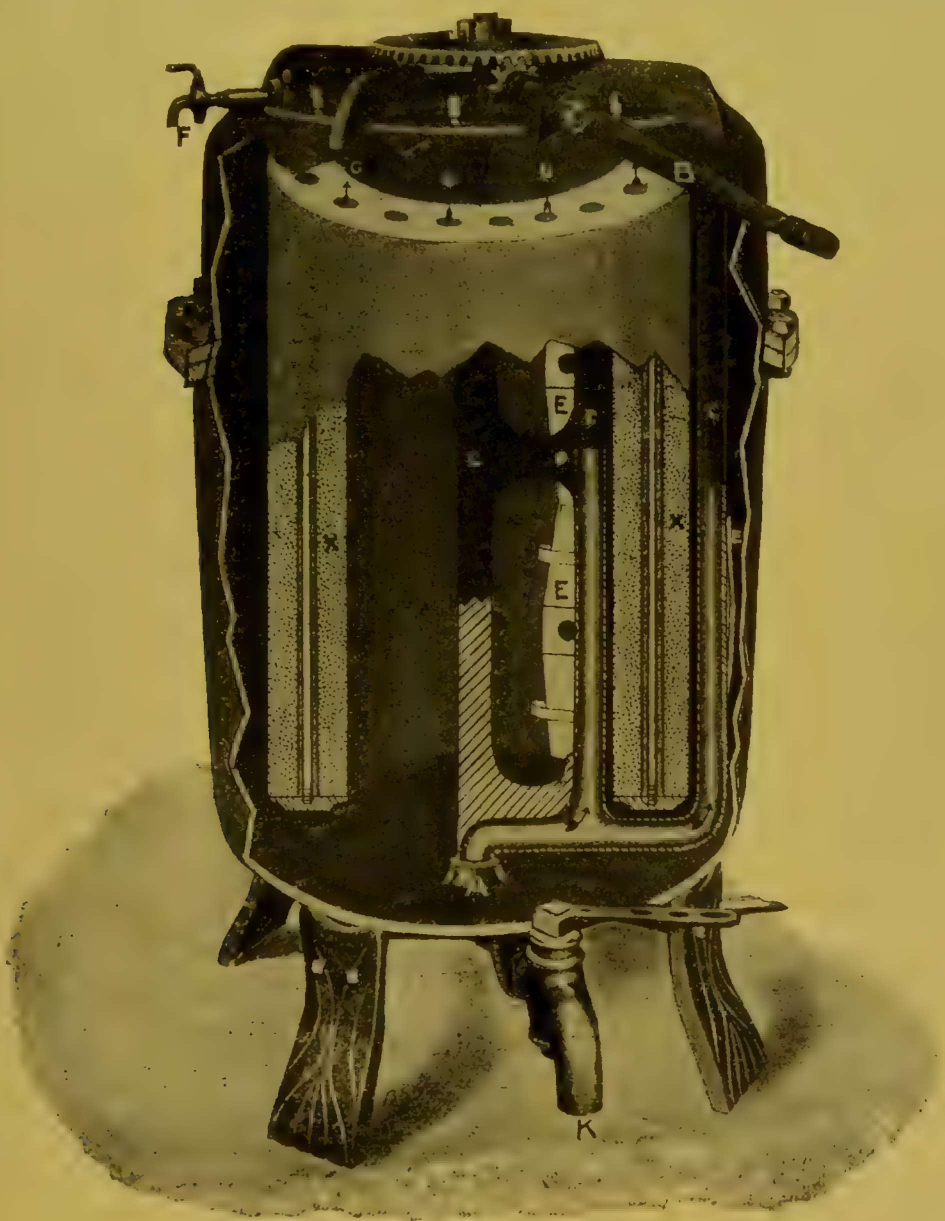

FIG. 41.—Sectional view of Lynn filter, showing porcelain cylinder with cores (G), tubular frame (C), scrapers (E) and flush-valve (K).

to 2, 1 or even less in the course of three or four days; at the same time the bougie becomes covered with a coating of the impurities in suspension, and germs begin to appear in the filtered water. These germs

did not pass through with the raw water but result from the growth of those deposited upon the surface, gradually extending along the pores through the walls of the bougie. They are nearly always harmless water saprophytes, the conditions being generally unfavorable to the multiplication of pathogenic bacteria. It is quite possible, however, that, under favorable conditions such as suitable temperature of the water and sufficient nutrient medium, the germs of typhoid fever and cholera could also grow through these filters. It is necessary therefore that they should be brushed every day, and sterilized in boiling water at least every 3 or 4 days. This cleansing and sterilization require special care, such as can seldom be given in households or military organizations, so that, outside of laboratories, these filters are seldom of much practical utility.

In the *Cincinnatus filter* type (Fig. 40), the water when filtered passes into the reservoir above. It is cleaned by opening the flush cock and revolving the wheel; this, by special device, reverses the filtered water and scrapes the mud off the surface of the tube. Such filter can be depended upon for thorough clarification and a fair degree of bacterial efficiency.

In one of the *Lynn filter* types, the porcelain cylinder is one or two feet in diameter, with core holes running lengthwise through the thickness of the wall (Fig. 41). In operation, the tap water is brought to bear on the inner and outer surfaces simultaneously, and forced into the core holes (G), the filtering area being thus enormously increased. A tubular frame (C), to which phosphor-bronze scrapers (E) are attached, can be made to revolve inside and outside the cylinder. For cleaning, the filtered water is forced backward into the core holes and through the walls, while the revolving frame scrapes the surfaces and washes them with many jets. These filters yield from 30 to 100 gallons an hour according to size and pressure. Their bacterial efficiency is reported as being at least 90 per cent.

SAND FILTRATION.

Sand filtration is the method of water purification on a large scale used by towns and other large communities. It is applied in two different ways, either according to the original sand-bed or English system, or the more recent mechanical or American system.

In the English system, the plant consists of a certain number of sand beds, each capable of independent operation (Fig. 42). The average sand bed is one acre in area and about four feet deep. It consists, from the bottom upward, of broken stone, gravel and sand; the broken stone and gravel forming a layer one foot thick, and the sand another layer three

feet deep. The broken stone is graded from one or two inches in diameter to about 1/5 of an inch or less. The sand should be clean, free from lime and clay, the grains ranging from 0.30 to 0.40 millimeter. The finer the sand the better the purification and the lesser the depth of the surface layer becoming soiled, but the smaller the output. The bed is thoroughly underdrained with lateral drains of open-jointed tile emptying into a central conduit. The bottom and sides of the compartment containing the bed are carefully cemented and made water-tight. A roof is necessary wherever the winter is severe and much ice forms; by excluding light it also prevents the growth of algæ and other microscopic plants, sometimes very troublesome in summer. In England and Holland the

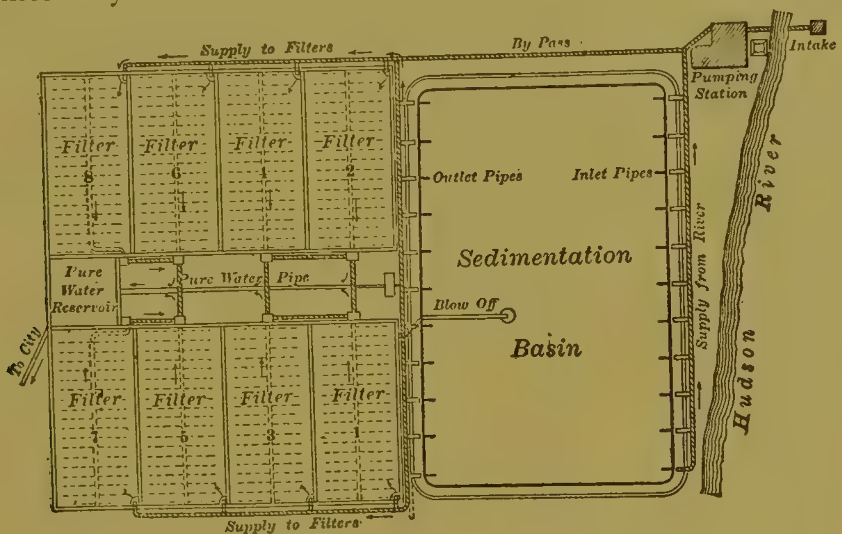

FIG. 42.—Plan of filter beds at Albany, N. Y.

beds are mostly left open. Unless the water is pretty clear one or more settling basins are necessary; the more complete is this preliminary sedimentation the more rapid and effective will be the functioning of the filter. Turbid water clogs the sand bed and requires frequent and expensive cleaning.

The suspended matters in water are retained on the surface of the sand, forming a sediment which becomes a much finer strainer than the sand itself. This sediment (Schmutzdecke of the Germans) consists of mineral and organic substances in variable proportions according to the character of the water. In water relatively clear, as in most of our eastern rivers, it is mostly made up of organic matter, especially microscopic algæ and diatoms, which by the swelling up of their cell membranes form a slimy gelatinous layer in which nearly all the micro-organisms of the water are caught. This gelatinous layer plays an important part in the

process of sand filtration, for it is after its formation that the filter reaches its highest degree of efficiency, the bacteria caught in its meshes being promptly oxidized and destroyed. But, after a while, this layer becomes so thick and impervious that the rate of filtration is very much reduced. It is then necessary to clean the bed, that is, remove the gelatinous sediment and one or two inches of the surface sand. When the water contains much fine silt and the organic gelatinous sediment is scant, several inches of sand may become clogged and require removal. Sand filters are generally cleaned every 3, 4 or 5 weeks in winter, depending upon the amount of impurities in the water, and much less frequently in summer. In improved plants (as in Washington, D. C.), the process of cleaning is largely mechanical and automatic; the sand is shoveled into movable ejectors, aspirated into washers, then conveyed into bins for storage and distribution. The filters may be scraped several times before new sand is put on, provided the sand bed is never reduced to a thickness of less than two feet.

After the cleaning, leveling and smoothing of the surface, the bed is refilled with *filtered water*, from *below*, through the underdrains. This is in order not to break or roughen the surface. After cleaning there is a reduction in the bacterial efficiency of the filter; more bacteria will pass through if full pressure is put on at once; it is better, therefore, to start again slowly and gradually increase the rate.

In most of our southern and western rivers the abundant clay and sand in suspension absorb most of the organic matter so that no gelatinous layer forms. The water of such rivers would clog the filter in a few days and must therefore receive special treatment. It is first run through one or more settling basins, and then a coagulant is added to it, as in mechanical filtration. The coagulant causes the microscopic atoms of silt (smaller than the pores of the sand) to coalesce in larger particles and these, together with the flocculent precipitate, form a sediment which takes the place of the gelatinous layer of clear rivers. This addition of a coagulant, previous to sand filtration, is always desirable in turbid waters.

Lime and sulphate of iron, in combination, have been used to precipitate sewage for many years. Lately this combination has been adapted to water purification, on account of its cheapness and the softening action of the lime when added to water containing an excess of carbonates. The iron hydrate is the active coagulating agent; if magnesium is present, magnesium hydrate also acts as a coagulant. The process is particularly adapted to turbid waters containing calcium and magnesium bicarbonates and is largely used in the middle and western States. At Saint Louis,

Mo., it is claimed that it removes 99 per cent. of bacteria and reduces the turbidity from 1,200 to 10.

Good sand filtration should remove at least 99 per cent. of the micro-organisms of the raw water, so that the remaining bacteria will not exceed 50 to the cubic centimeter.

The filter plant of Washington, D. C., one of the latest and most complete in this country, consists of 29 sand beds, each one acre in size, in basins of concrete, completely covered. The water is taken from the Potomac River, 14 miles above the city, and allowed to settle in three successive reservoirs. The beds are cleaned every six weeks in winter and only once or twice in summer, the thickness of sand removed, owing to the large proportion of fine clay in the raw water, being 6 to 12 inches. This cleaning is mostly automatic as noted above. The cost of operation, including interest on cost of construction, is 0.9 of a cent per 1,000 gallons. The output exceeds 200 gallons per capita. During the year 1906, the number of bacteria in the filtered water ran from 17 to 39 per cubic centimeter

MECHANICAL FILTRATION.

This system is of American origin and extensively used in this country. It is particularly adapted to very turbid waters in which no organic gelatinous sediment forms, as well as to highly colored waters; it is the most practicable system of purification for the water of the lower Mississippi and many other western rivers. It is also the system best adapted to military posts or small communities. It consists in rapid sand filtration, after sedimentation and the addition of a coagulant. Its efficiency depends chiefly upon the use of coagulants; these do not effect purification by destroying or inhibiting the bacteria contained in the water; they simply cause the formation of a precipitate of a more or less flocculent character which entangles and surrounds all suspended particles, including the bacteria. Thus clay, sand, considerable organic and coloring matter, and bacteria, are removed; but the bacteria thus carried down are not killed, for cultures can be made from the precipitate. Water thus treated and allowed to stand until the precipitate has settled to the bottom is clear and brilliant, and nearly sterile (Darnall).

The coagulants most commonly used are alum (aluminum and potassium sulphate), aluminum sulphate and iron sulphate. When either of these chemicals is added to the water, it is decomposed by the action of the carbonates present in the water, with formation of a flocculent percipitate of aluminum hydroxid or ferrum hydroxid, and of another of basic sul-

phates, the latter to some extent helping the former in carrying down the suspended impurities. Should the water be lacking in natural carbonates it will be necessary to add them.

In the mechanical (gravity or open) filter plant, the raw water is conveyed or pumped into settling tanks, entering near the bottom after having received a graded quantity of coagulant, usually one to two grains per gallon. It rises until it overflows into the filter tanks, leaving behind, in the settling tanks, much of the precipitated suspended impurities. The filter tank is circular, of wood or steel (Fig. 43), or rectangular, of concrete. It is filled with sand through which the water passes at a rate fifty to sixty

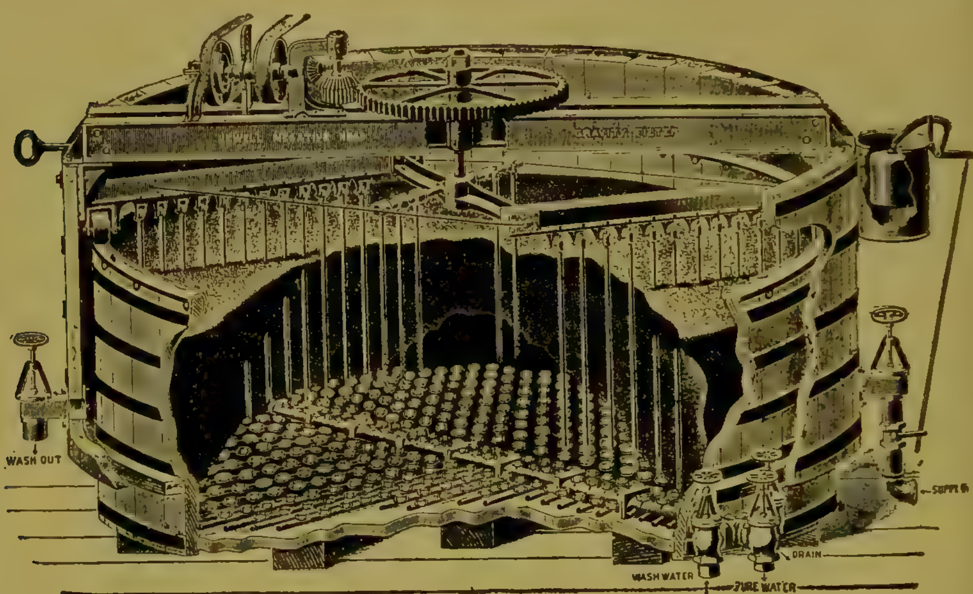

FIG. 42.—Jewell gravity filter, with rake. (N. Y. Continental Jewell Filteration Co.)

times faster than through an ordinary bed filter, the best average rate being 105 gallons an hour per square foot of area. The sand is somewhat larger than in the ordinary filter but should be of more uniform size to prevent "breaking" or "channelling" in the process of washing. Whenever the sand becomes clogged, once or twice a day, it is cleaned, in circular tanks, by using a reverse or upward current of filtered water, being meanwhile thoroughly stirred by a revolving rake, the impurities overflowing over the edge of the tank.

In plants using concrete rectangular tanks, the revolving rake is replaced by the "air wash" device, the sand being washed by driving innumerable jets of air and water alternatly through it from the bottom, the air for agitation and scrubbing and the water for rinsing. This system is likewise applied to circular tanks (Fig. 44).

The so-called pressure mechanical filter is in an entirely closed receptacle through which the water is forced under pressure (Fig. 45). When

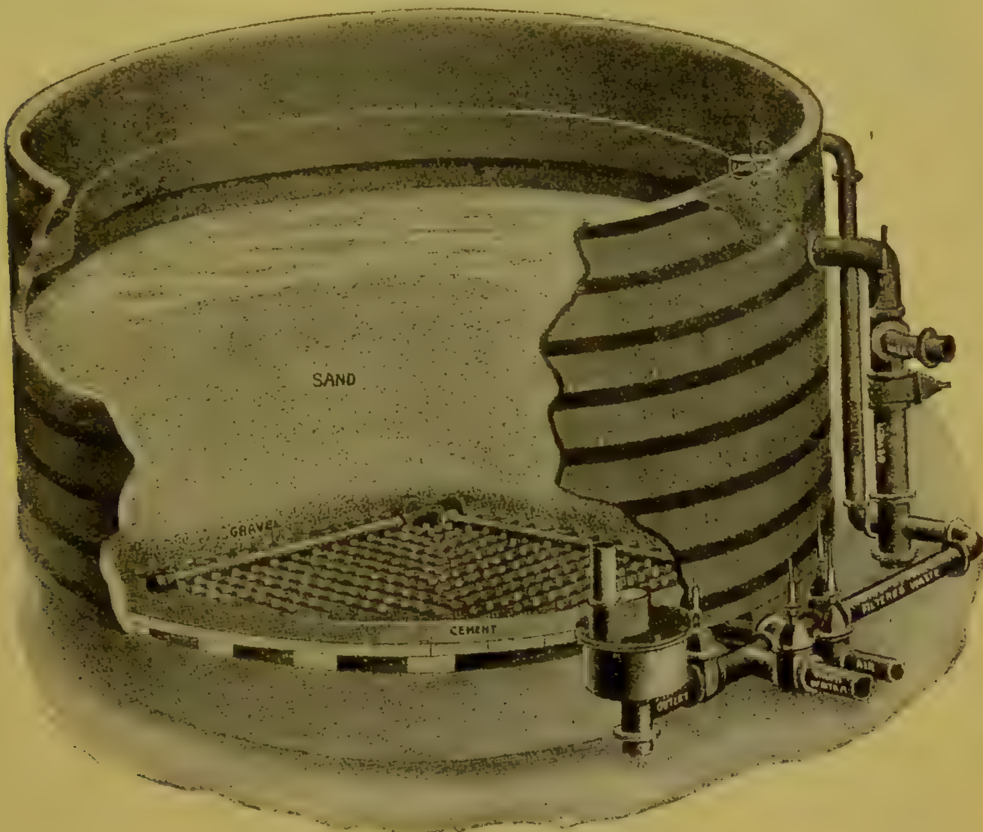

FIG. 44.—Continental "air wash" gravity filter.

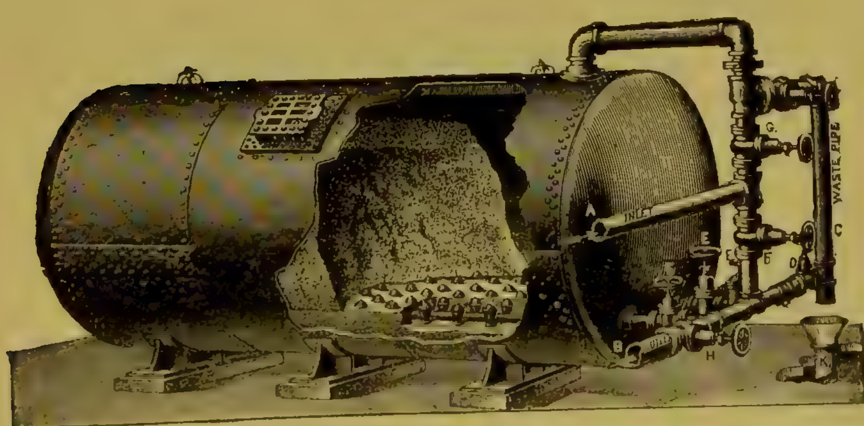

FIG. 45—New York sectional wash horizontal pressure filter.

the location is favorable, as when the plant is below the source of supply, this system is indicated and very satisfactory. Pressure filters are readily

cleansed and operated, and in the case of small communities quite economical.

The efficiency of the mechanical filter is not quite as high as that of the best sand-bed filter, seldom removing more than 98 per cent. of the bacteria; but it is 25 per cent. cheaper in total first cost and requires an area of only about one-thirtieth the size.

THE DARNALL FILTER.*

This apparatus is an ingenious adaptation of the principle of mechanical filtration to the needs of troops in the field. It consists of a galvanized-iron tank, two water cans, a siphon filter and cloth, a siphon primer (small

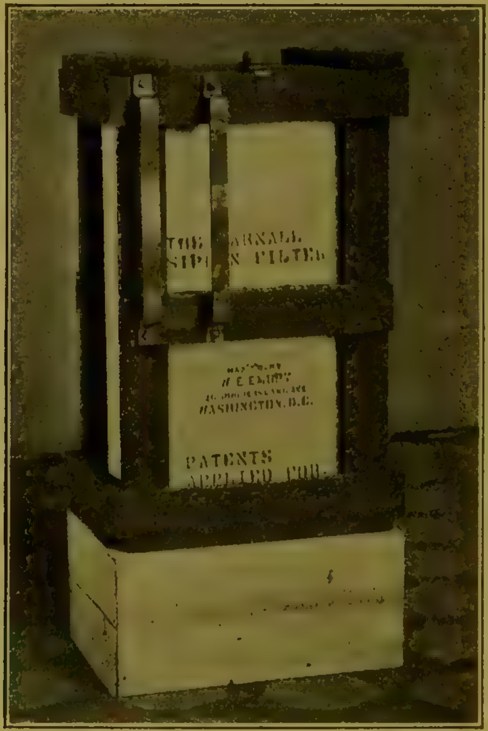

FIG. 45.—The Darnall filter, packed.

hand pump to start the flow of water) and a crate (Figs. 46, 47, 48). The essential part is the cylindrical metal framework of the siphon over which is wrapped the filtering material, a closely woven cotton fabric. This is placed in the tank filled with raw water to which the precipitant has already been added, and the water, after passing through the filtering cloth into the cylinder, is discharged by siphonage into the water can.

*Devised by Major Carl R. Darnall, Medical Corps, U. S. Army.

As matters in suspension deposit upon the cloth and the flow of water becomes much diminished, the filter should be taken out and brushed; but when the brushing no longer restores a full flow, the cloth must be removed, washed and put aside to dry; a new cloth is put on and sterilized in the can by siphoning boiling water through it.

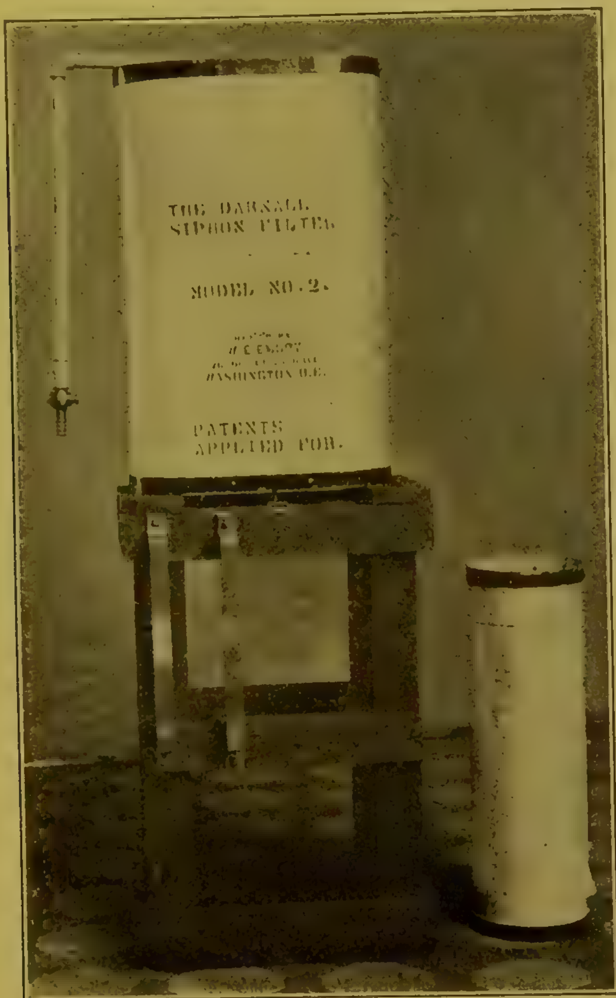

FIG. 47.—The Darnall filter, ready for operation.

The precipitant consists of alum and sodium carbonate in such proportions as to neutralize each other. Five grains of alum to the gallon is sufficient for the most grossly polluted water. Each gallon of water treated with this amount of alum and its equivalent of soda and then filtered, will contain in addition to its original chemical constituents about 2.5 grains of sodium sulphate, 0.93 of potassium sulphate, and 0.7 of

carbon dioxid, all of which are harmless if not beneficial. The alum and soda may be used in separate solutions fed automatically, but for use with marching troops and in temporary camps it is more convenient to use them already mixed, in the form of a stable powder, one pound of which is sufficient for 500 gallons of water.

This filter complete (with crate) weighs 52 pounds and will deliver about 200 gallons of water in four hours. It completely clarifies the water. Its bacterial efficiency is about 98 per cent. with ordinary waters,

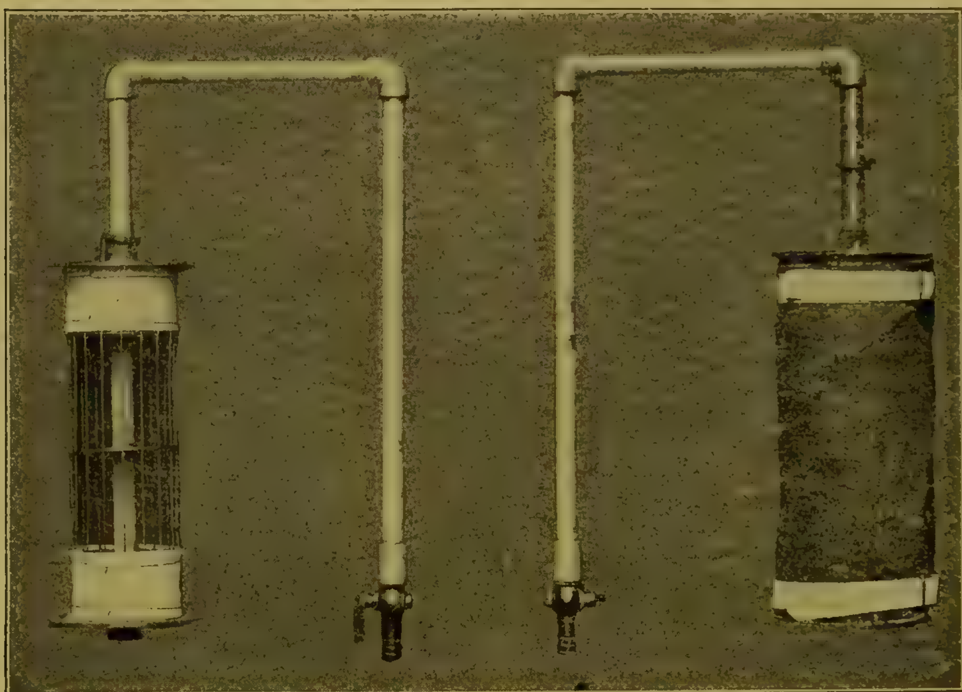

FIG. 48.—Filtering cylinder of the Darnall filter, with and without filtering cloth.

and more under favorable conditions, therefore comparing favorably with most municipal filtering plants. This apparatus cannot be depended upon for the certain elimination of all pathogenic bacteria, as with heat sterilizers, but it purifies ordinary waters to a degree that renders them reasonably safe. It does not require any fuel except for heating water to sterilize the filter cloths, once daily; it furnishes plenty of clear water, unchanged in temperature and taste, within an hour after getting into camp; the whole outfit is simple, cheap, easily transportable and workable in any situation. It has been carefully investigated by a board of medical officers and its use in the field recommended.

THE JAPANESE FIELD FILTER (Eshitzi Filter).

During the Russo-Japanese War, the Japanese used another simple and practical adaptation of the principle of the mechanical filter (Fig. 49) It consists essentially of a conical canvas bag of a capacity of 24 gallons, with two spouts or branches near the point; these spouts are filled with charcoal and sponge disks and constitute the filters proper; the point, or

FIG. 49.—The Japanese field filter. (*Eshitzi filter.*)

apex, receives the sediment. The whole apparatus is suspended between the branches of a tripod.

Two powders are used. The first (A) consists of potassium alum, potassium permanganate and (to give bulk) aluminum silicate; the second (B), chiefly of aluminum silicate and of small amounts of tannic acid and hydrochloric acid. The filter having been filled, a suitable quantity of

powder A, enough to plainly discolor the water, is added and stirred up; after a few minutes, about half as much of powder B is stirred in until the discoloration caused by the first has been removed. Then the water is allowed to stand 15 or 20 minutes for the bactericidal action and subsidence of the precipitate, after which the lateral spouts are untied and the water allowed to pass through. The hydrochloric acid in powder B facilitates the decomposition of the permanganate, while the tannic acid removes the color imparted to the water.

The result is quite satisfactory with comparatively clear water, but much less so with turbid water. The output is small and the disinfection of the apparatus difficult.

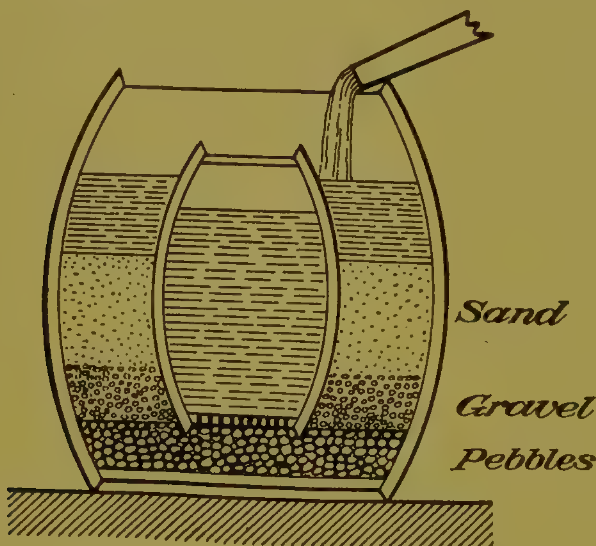

FIG. 50.—Double barrel improvised filter.

MAIGNEN FILTER.—There are also various forms of "granular" filters, of which the Maignen, formerly used in the Army, is the type. It consists of a central framework around which is tied a core of asbestos; this is surrounded by granular charcoal, or charcoal compound, the whole enclosed in a bag of asbestos cloth. The water penetrates to the interior and is discharged by siphonage. These filters are useless, when not dangerous, generally yielding more bacteria, saprophytic and pathogenic, than are contained in the raw water.

IMPROVISED FILTERS.

In camps, filters for the clarification of water can be readily improvised if sand be available, and a certain degree of purification can likewise be obtained. But, on the other hand, it must be remembered that such

filters, unless they can be washed or sterilized, may soon become infected and that clarification may be obtained at the expense of purification.

Hard, clean sand is the best material for improvised filtration. Bone charcoal has a greater power of removing coloring matters, but on account of its porous nature soon absorbs the impurities of the water and becomes infected, when the only way of sterilizing it is by calcination. If sand be placed over pebbles and coarse gravel in a barrel, we have the usual sand filter on a small scale; through the perforated bottom the filtered water is discharged into another barrel or can. If the water is turbid it should first be treated with alum, 2 or 3 grains to the gallon. In the absence of sand, this treatment by alum may be sufficient of itself, but with water likely to be contaminated with sewage, it should be followed by boiling.

If a hogshead and a barrel are available, the latter, with perforated bottom, is placed inside the former upon a bed of coarse gravel or pebbles and the interspace filled with gravel and sand; the water is gently poured

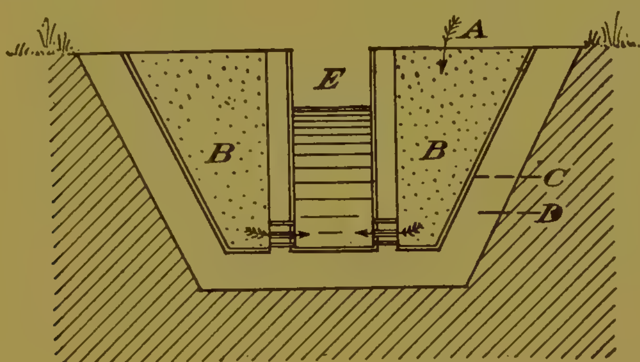

FIG. 51.—Venetian cistern.

or sprinkled over the sand and, after filtration, rises up to its level in the barrel. (Fig. 50.) The upper layer of sand should be frequently scraped out and washed or replaced by fresh, clean sand.

Another expedient is to dig a pit at a distance of a few feet from the river's edge, where the bank is sandy, and let the water percolate through the intervening sand into it; or, again, a trench may be dug connecting the river with the pit, then boxed and filled with sand.

The so-called "Venetian cistern" can also be readily improvised in certain situations. It consists (Fig. 51) of a pit with walls of clay (D) lined with cement (C), and of a circular wall of clay, likewise cemented, in the center; the interval is filled with clean sand and receives the raw water which, after filtering through, passes into the central well (E).

CHAPTER XIV.

FOOD.

Food is any digestible substance introduced into the alimentary canal for the nourishment of the body.

All foodstuffs may be conveniently divided and classified as follows:

Organic (animal and vegetable).	Nitrogenous.	Proteids or proteins.
	Non-nitrogenous.	Hydrocarbons—fats. Carbohydrates—sugars and starches. Vegetable acids.
Inorganic (mineral).	Mineral salts. Water.	

Organic foodstuffs are primarily divided into two great classes, according to the presence or absence of the all important element nitrogen. They consist of a few constituents, or "proximate principles," existing ready formed in nature. The three important proximate principles entering into the composition of all animal and vegetable foods are the proteids, hydrocarbons and carbohydrates. None of these principles is ever found alone in nature, but they are always associated in variable proportions, as in bread, meat, milk and vegetables, for man is omnivorous and needs them all for his best physical development. (Fig. 52).

PROTEIDS.—They form the chief part of every animal cell, being the principal constituent of muscle, and making up about 18 per cent. by weight of the body. They are found under many forms in all animal and vegetable foodstuffs. Animal and vegetable proteids are identical in chemical composition and, when equally digestible, have about the same nutritive value.

Chemically, they consist of oxygen, hydrogen, carbon, nitrogen and sulphur, in about the average respective percentages of 23, 7, 52, 16, 0.5 to 2.0. Nitrogen is their characteristic element. The so-called nucleo-proteids, occurring in the nuclei of cells, contain likewise a small amount of phosphorus in organic combination. Proteid substances have features in

common but differ more or less in solubility and decomposition products. By digestion they are transformed into proteoses and peptones which, by oxidation and the hydrolytic action of specific ferments (enzymes), break up into amino-acids, with the final end-products of carbon dioxid, water and urea, and small proportions of uric acid and creatinin.

Proteids are divided into true proteids and albuminoids (sometimes called albuminoids and gelatinoids respectively): 1. True proteids are

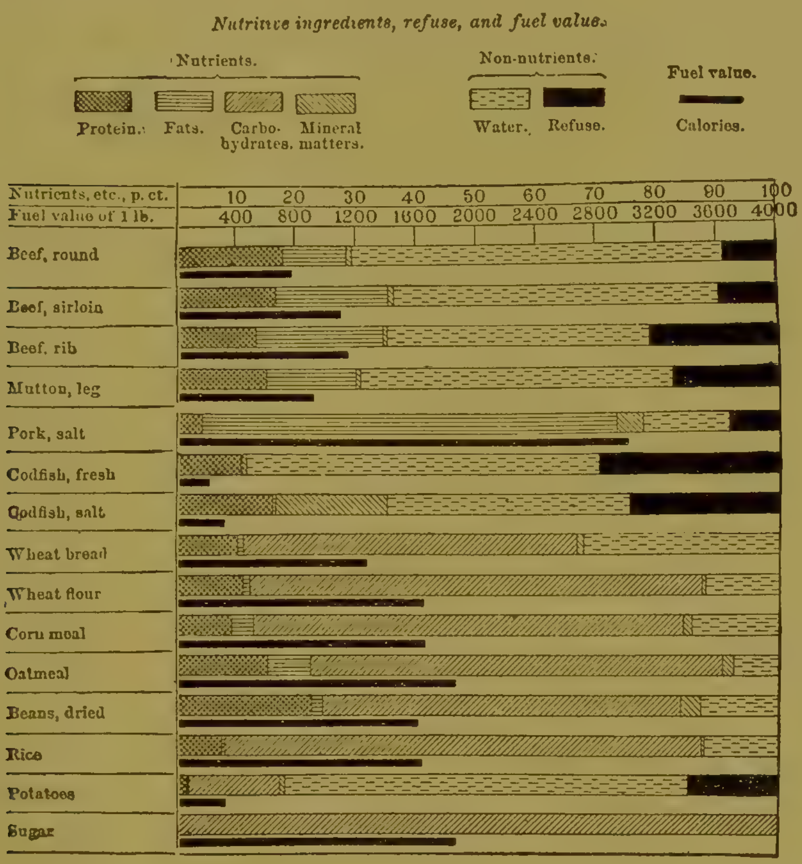

FIG. 52.—Composition of the chief foodstuffs entering into the United States Army ration. (*Atwater.*)

indispensable to the body and habitually used for food. They include the albumin of egg and of the blood, myosin of muscle, vitellin of egg, globulin of cereals, paraglobulin and fibrin of blood, gluten of wheat, casein of milk, legumin of beans and peas, etc. 2. Albuminoids (gelatinoids) contain at least as much nitrogen as the true proteids but, for reasons not well understood, have very little nutritive value. They include ossein from bone; gelatin and chondrin from connective tissue, cartilage and ligaments; isinglass from the air-bladder and other tissues of fish.

Hydrocarbons or Fats.—Fats, in nature, occur mostly under three forms, stearin, palmitin, and olein, which are compounds of glycerin with stearic, palmitic and oleic acids respectively. These three compounds are always more or less combined in nature. Stearin and palmitin are solid, while olein is liquid at ordinary temperature. They are free from nitrogen, consisting chiefly of hydrogen and carbon, with a proportion of oxygen too small to combine with the hydrogen to form water, their general formula being $C_{10}H_{18}O$. Fat forms about 15 per cent., by weight, of the body of man. All foodstuffs, animal and vegetable, contain fat in variable proportions; especially rich in it are meats, milk, eggs, nuts and such cereals as corn and oats; while some, like olive oil, cotton-seed oil, butter, bacon, suet and lard consist chiefly of it.

Carbohydrates are so called because, in addition to carbon, they contain hydrogen and oxygen in proportion to form water, that is, twice as many atoms of hydrogen as of oxygen. They occur abundantly in plants, chiefly as sugars and starches, but form less than 1 per cent. of the body tissues.

Grape sugar, *glucose* or *dextrose* ($C_6H_{12}O_6$), the common sugar of fruits and flowers, characterized by its property of reducing solutions of copper sulphate, and manufactured on a large scale by the action of dilute acids on starches. It is found normally in animal tissues, generally from the transformation of other carbohydrates, or as a morbid product excreted by the kidneys, as in diabetes.

Cane sugar or *saccharose* ($C_{12}H_{22}O_{11}$), the crystalline sugar of sugar-cane, beet-root and the sap of maple, birch and other trees. It does not reduce solutions of copper sulphate, but is easily transformed into glucose by fermentation or the action of dilute acids.

Milk sugar or *lactose*, only found in milk.

Cane sugar and milk sugar when taken into the alimentary canal are not utilized as such, but promptly converted into forms of glucose. Sugar, as glucose or dextrose, is one of the normal constituents of the blood, its quantity being regulated by the liver so that a definite proportion is maintained in spite of all fluctuations in the supply. This function of the liver consists in transforming the excess into glycogen or animal starch ($C_6H_{10}O_5$), and storing it up as reserve material to be reconverted into sugar when needed by the body.

Starches ($C_6H_{10}O_5$) exist in all plants, being the principal constituent of seeds and cereals, as well as many tubers and roots. They are mostly derived from wheat, corn, potatoes, the roots of cassava and arrowroot, and the pith of the sago-palm. They occur in characteristic granules

made up of concentric layers, of variable size and shape according to the plants producing them (Fig. 53). Starches are insoluble but, when heated in water, the granules swell up, burst their membranes and form an easily digestible paste. With tincture of iodine they yield a characteristic intense blue color. In the body they are acted upon by ferments (enzymes) and converted, at first into a gum-like substance (dextrine), then into dextrose and glucose.

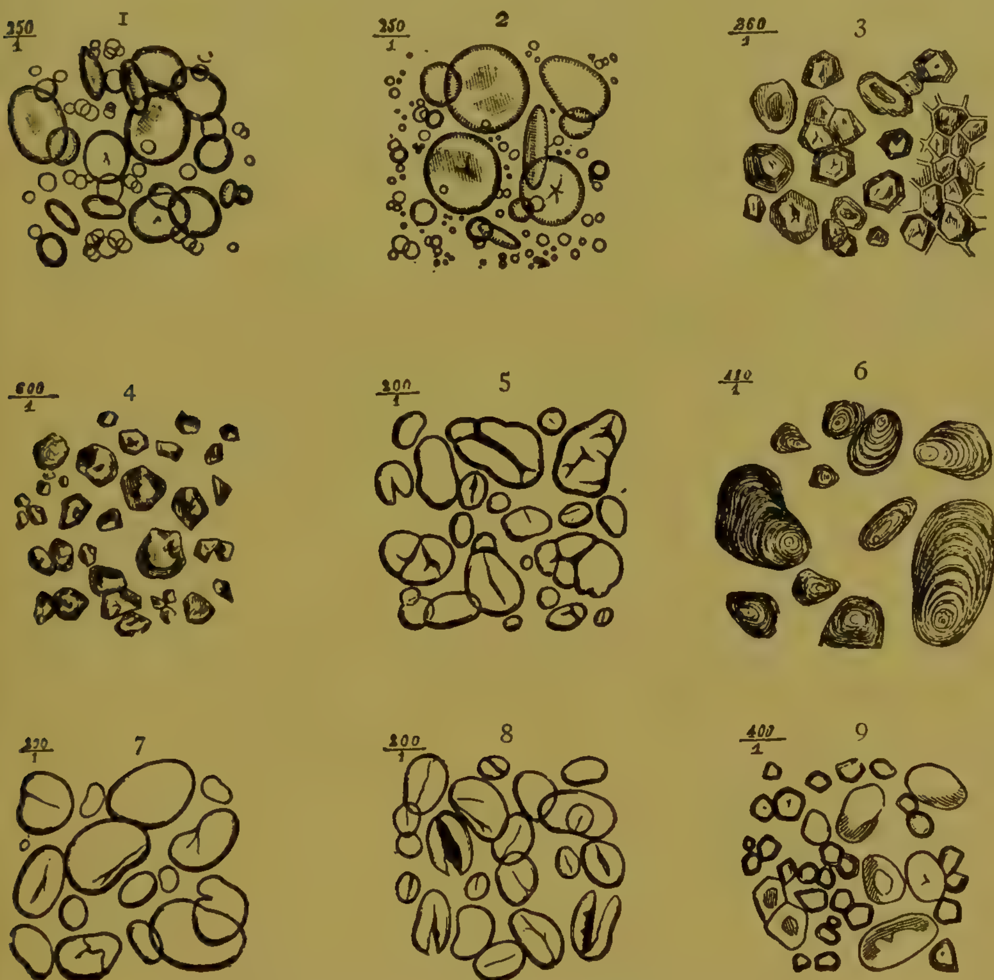

FIG. 53.—Starch grains of various vegetables. 1, wheat; 2, rye; 3, corn; 4, rice; 5, horse-bean; 6, potato; 7, bean; 8, pea; 9, buckwheat.

Other carbohydrates worth mentioning are: *cellulose* which forms the framework of plants and constitutes the fiber of flax, hemp, cotton, the hull of seeds, etc., being quite insoluble and of no dietetic value; *pectin* which forms the jelly of various ripe fruits.

Vegetable Acids consist of the same chemical elements as carbohydrates but the oxygen is in quantity more than sufficient to convert the hydrogen into water. They are derived from fruits and other parts of plants. Those most used as foods are: tartaric acid, found in grape juice as potassium tartrate; citric acid, found in the orange, lemon and other fruits of the citrus genus, as well as in gooseberries and potatoes; malic acid, found in the apple and pear; oxalic acid, found in rhubarb, tomatoes, sorrel and other plants with acid foliage; acetic acid, the active constituent of vinegar.

They exist in the free state or, more commonly, in combination as salts. In the body, they are decomposed and become oxidized into carbonates which help to maintain the alkalinity of the blood and other fluids. Their absence in foods is soon severely felt, resulting in a lowering of vitality, malassimilation and symptoms of scurvy.

Mineral Salts.—The salts most necessary for the body are sodium and potassium chlorides, iron, and phosphates of lime, potassium, sodium and magnesium. Chlorides are indispensable to keep in solution the globulins and albumin of the blood and other fluids, as well as to supply the hydrochloric acid of the gastric juice. The phosphates are needed for bone growth and repair, while phosphorus is a constituent of nerve tissue. Phosphate of lime is found in all tissues and seems essential to cell growth. Iron is a necessary constituent of the coloring matter of the hemoglobin of the red blood-corpuscles. All these salts, with the exception of sodium chloride which is used as a condiment, exist generally in sufficient quantity in drinking water and the ordinary articles of food.

NUTRITIVE FUNCTIONS OF FOOD PRINCIPLES.

The *proteids* are the tissue formers and repairers. They form the chemical basis of all living cells, whether animal or vegetable, and are absolutely necessary for the building and renewal of tissues and organs. No life is possible without them. Under exceptional circumstances proteids can be converted into carbohydrates as, for instance, in the case of diabetic patients who although fed on an exclusively proteid diet continue to excrete sugar.

Fats and *carbohydrates* are the sources of heat and energy, the natural fuel foodstuffs of the body, by their oxidation maintaining the body temperature and evolving power to run the bodily machinery. The greater the muscular exertions, and the colder the weather, the larger is the amount needed and consumed. They undergo complete com-

bustion in the body to simple gaseous products, namely carbon dioxid and water. Fats containing much more carbon than carbohydrates have a much greater fuel value per pound but are less easily oxidizable. Like proteids they form an essential part of the structure of tissues, the surplus becoming stored in them for the needs of the body economy. They are specially concerned in the growth and repair of brain and nerve tissues, forming one-fifth of the solid matter of the brain, and are likewise of much value in wasting diseases such as tuberculosis. Much fat may be derived from carbohydrates as seen by the increased plumpness of men employed in sugar mills, as well as by the amount of cream in the milk of cows simply fed on grass, this amount being much in excess of the fat contained in the grass. When not required in the system, fats are absorbed with difficulty and render many articles of food indigestible, or "too rich." The free use of water seems to favor the deposit of fat in the body, while, on the other hand, a diet consisting chiefly of lean meat causes rapid oxidation of fat and reduces obesity.

Carbohydrates are all absorbed and probably oxidized as sugar. From the ready conversion of sugar into fat, it does not follow that these principles are interchangeable in the diet; both have doubtless different functions to perform before their final reduction to carbon dioxid and water. Sugar is of special importance as muscle food, rendering men capable, at least for a few days, of unusual muscular exertion, and alleviating hunger, thirst and fatigue. When soldiers are called upon to do strenuous work, nothing is better than small cups of black coffee strongly sweetened with sugar or glucose.

ANIMAL FOODS.

For our purpose, animal foods may be classified as follows: 1. Meats, including poultry and game. 2. Soups and meat extracts. 3. Fish, mollusks and crustaceans. 4. Milk and its derivatives. 5. Eggs.

MEAT.

Meat consists of muscular fibers (each fiber a bundle of microscopic tubes), connective tissue which holds the fibers together, and fat cells in the connective tissue.

The muscular fiber contains proteids, salts and extractives. The chief proteid is myosin and the principal salt potassium phosphate. Extractives are nitrogenous substances derived from proteids and "ex-

tracted" by boiling water; they have very little nutritive value but give to meats their characteristic flavors, increasing with the age of the animals and varying much in quality according to the food of the latter; thus lamb and veal are less flavored than mutton and beef, while game animals feeding upon wild herbs are more savory than domesticated ones. The younger the animal the more watery is its flesh and the lower its nutritive value. The amount of fat in meat is quite variable, ranging, according to the condition of the animal, from 1 to 25 or more per cent.; its increase is always at the expense of water, the more fat the less water and conversely.

The composition of the meats and fish most used is as follows (from Bulletin 28 (revised edition), U. S. Department of Agriculture):

	Water	Proteids	Fat	Mineral matter
Beef:				
Chuck and shoulder	65.	19.2	15.40	0.90
Chuck rib	66.80	19.0	13.40	1.00
Flank	59.30	19.60	21.10	0.90
Loin	61.30	19.	19.10	1.00
Sirloin steak	61.09	18.90	18.50	1.00
Sirloin steak, baked	63.70	23.90	10.20	1.40
Tenderloin steak	59.20	16.20	24.40	0.80
Tenderloin steak, broiled	54.80	23.50	20.40	1.20
Ribs	57.	17.80	24.60	0.90
Round	67.80	20.90	10.10	1.10
Corned beef	53.60	15.60	26.20	4.90
Pork:				
Ham, medium fat	53.90	15.30	28.90	0.80
Ham, medium fat, smoked	40.30	16.30	38.80	4.80
Bacon, medium fat, smoked	18.80	9.90	67.40	4.40
Veal, leg, medium fat	70.00	20.20	9.00	1.20
Mutton:				
Loin, medium fat	50.20	16.	33.10	0.80
Leg, medium fat	62.80	18.50	18.00	1.00
Leg, roasted	50.90	25.00	22.60	1.20
Lamb, leg, medium fat	63.90	19.20	16.50	1.10
Chicken, broiler	74.80	21.50	2.50	1.10
Young goose	46.70	16.30	36.20	0.80
Turkey	55.50	21.10	22.90	1.00
Salmon	65.76	20.77	12.09	1.38
Spanish mackerel	68.10	20.97	9.43	1.50
Lake trout	69.14	18.22	11.38	1.26
Shad	70.62	18.55	9.48	1.35
Turbot	71.38	12.92	14.41	1.28
Herring	72.10	18.19	8.02	1.69
Smelt	79.16	17.36	1.80	1.68
Cod	82.46	16.	0.30	1.24

Digestibility.—The nutritive value of food does not only depend upon its constituents but also upon its availability, that is, the extent to which it is digested and absorbed. Thus roast mutton and dried peas contain approximately the same amount of proteid, but their nutritive value is very different. As a rule, animal foods are more digestible and completely absorbed than vegetable foods; thus, of animal foods, 97 per cent. of the proteins, 95 of the fats and 98 of the carbohydrates are digested, while, of vegetable foods, only 84 per cent. of the proteins, 90 of the fats and 97 of the carbohydrates are digested (Atwater), the balance being discharged with the intestinal excreta.

Of the constituents of meat, the muscular fibers are most digestible and most nutritive. The shorter and thinner they are, the more tender the meat. The older the animal the thicker the walls of the tubes, the denser the connective tissue and the less digestible the meat. Connective tissue is readily dissolved in the stomach but has little nutritive value. A moderate amount of fat facilitates the digestion of meat; more than that hinders the action of the gastric juice upon the fibers; therefore, except when much heat and energy are needed, fat beyond a small quantity is undesirable. The digestibility of meat is also favored by the amount of savory extractives which it contains, and by the acids which naturally form in it as first product of decomposition; therefore it never should be eaten fresh, but always kept until it begins to soften, previous to actual decay.

Mutton is drier than beef and contains more fat; it is a pleasant substitute for it at times, but its exclusive or steady use is not so well borne. Pork differs from both in having less proteid and more fat, being therefore less digestible; somewhat different is bacon in which the fat is drier, more granular and generally accepted by delicate stomachs. Veal contains less proteid and more fat than beef and does not agree with everybody, while lamb differs but little from mutton. The white meat of poultry contains less fat than the dark meat and is more delicate and more digestible. Tripe and sweetbreads are easily borne, but liver and kidneys require a vigorous digestion.

The following table (Bull. 28, Dept. of Agric.) shows the proportion of digestible and indigestible constitutents of some common animal foods, with resulting fuel value:

Food materials	Refuse	Water	Total indigestible nutrients	Digestible nutrients: Protein	Fat	Carbohydrates	Ash	Fuel value per pound
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
Beef, fresh:								
Chuck, ribs	16.3	52.6	1.4	15	14.3	....	0.6	910
Loin, medium	13.3	52.5	1.6	15.6	16.6	....	.7	1,025
Ribs	20.8	43.8	1.8	13.5	20	....	.5	1,135
Round, medium	7.2	60.7	1.4	18.4	12.2	....	.8	890
Shoulder and clod	16.4	56.8	1.2	15.9	9.3	....	.7	715
Beef, dried and smoked	4.7	53.7	4.5	25.6	6.6	....	5.5	790
Veal:								
Cutlets, round	3.4	68.3	1.2	19.5	7.1	....	.8	695
Leg	14.2	60.1	1.1	15	7.5	....	.7	625
Mutton:								
Leg	18.4	51.2	1.4	14.6	14	....	.6	890
Loin	16	42	2	13.1	26.9	....	.5	1,415
Pork, fresh:								
Loin, chops	19.7	41.8	1.8	13	23	....	.6	1,245
Ham	10.7	48	1.9	13.1	24.6	....	.6	1,320
Pork, salted and smoked:								
Bacon	7.7	17.4	4.4	8.8	59.1	....	3.1	2,720
Ham	13.6	34.8	3.1	13.8	31.7	....	3.2	1,635
Salt, fat	....	7.9	5.4	1.8	81.9	....	2.9	3,555
Poultry:								
Fowl	25.9	47.1	1.2	13.3	11.7	....	.5	765
Turkey	22.7	42.4	1.6	15.6	17.5	....	.6	1,060
Fish, fresh:								
Cod, dressed	29.9	58.5	.5	10.8	.2	....	.6	220
Mackerel	44.7	40.4	.7	9.9	4	....	.5	370
Shellfish:								
Oysters, solids	....	88.3	.6	5.8	1.2	3.3	.8	225
Fish, preserved and canned:								
Cod, salt	24.9	40.2	5.1	15.5	.4	....	13.9	325
Salmon, canned	....	63.5	1.9	21.1	11.5	....	2.	915
Eggs, uncooked	11.2	65.5	1.1	12.7	8.8	.....	.7	635
Dairy products:								
Whole milk	....	87	.5	3.2	3.8	5	.5	310
Skim milk	....	90.5	.3	3.3	.3	5.1	.5	165
Cream	....	74	1.1	2.4	17.6	4.5	.4	865
Butter	....	11	4.9	1	80.8	....	2.3	3,410

Characteristics of Good Meat.—The lean of good beef which has been cut at least an hour (freshly cut meat is always dark), should have a bright, lustrous, cherry-red color, with a distinctly marbled appearance due to the lines of fat around the polygonal bundles of muscular fibers; it should be soft and silky to the touch, but, at the same time, firm and elastic, neither pitting nor crackling on pressure, the bright red juice slowly oozing out. Pale, moist muscle marks young sickly animals, while dark, tough, stringy meat probably comes from old ones, or perhaps from bull or horse. A deep, purple tint suggests that the animal has died from disease. The fat should be reasonably abundant, hard and firm; the fatter the meat, the smaller is the proportion of protein. Good meat has a slight but not disagreeable odor. In temperate climates the

marrow of the hind legs is still solid 24 hours after killing, and rosy red. The first evidence of decay is detected by thrusting a wooden skewer deep into the flesh, preferably alongside a bone, then withdrawing and smelling it. Veal and lamb are paler than beef and softer to the touch. Mutton is of a dull red color, with very white (occasionally yellowish), hard fat and no marbling. Pork is light red, softer than beef or mutton; its fat should be white and firm.

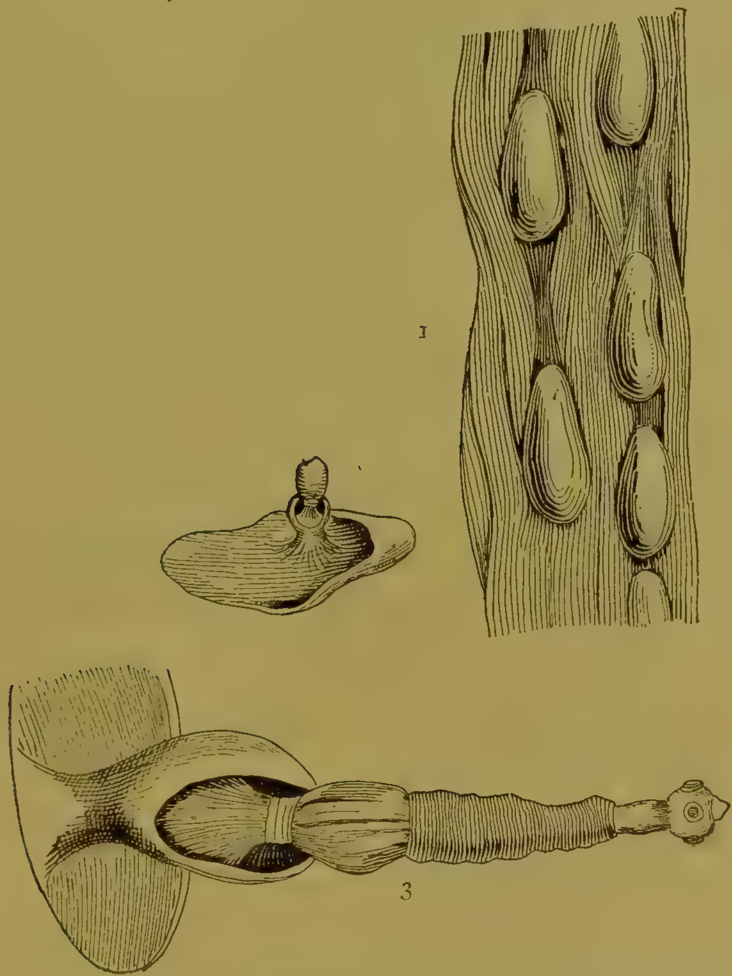

Fig. 54.—*Cysticercus* of pork; 1, cysts in muscle; 2 and 3, inner coat cut open and parasite extruded. (*Davaine.*)

Meat Parasites.—The meat parasites from which man most suffers are the tapeworms and *trichina spiralis*. Of the several species of tapeworms, only two are known to infect man in this country, namely *Tænia saginata* due to measly beef, and *Tænia solium* due to measly pork. In cattle and swine they only exist in the larval form known as *Cysticercus bovis* and *C. cellulosæ* (Fig. 54). Their life history is as follows: From

the adult tapeworm, in the intestines of man, a number of eggs are discharged; these are expelled with the feces and some find their way, with water or food, into the digestive tract of cattle or swine; there the embryos issue from the eggs and piercing the intestinal walls migrate to all parts of the body, where they grow as "bladder-worms." The whitish bladders, oval or elliptic in shape, vary in size from a large bean to a pin's head. The meat thus infected is said to be "measly"; if eaten raw or imperfectly cooked, by man, the cysticercus develops into the adult tapeworm, thus completing the cycle. Bladder-worms are readily killed by ordinary cooking and the meat rendered harmless.

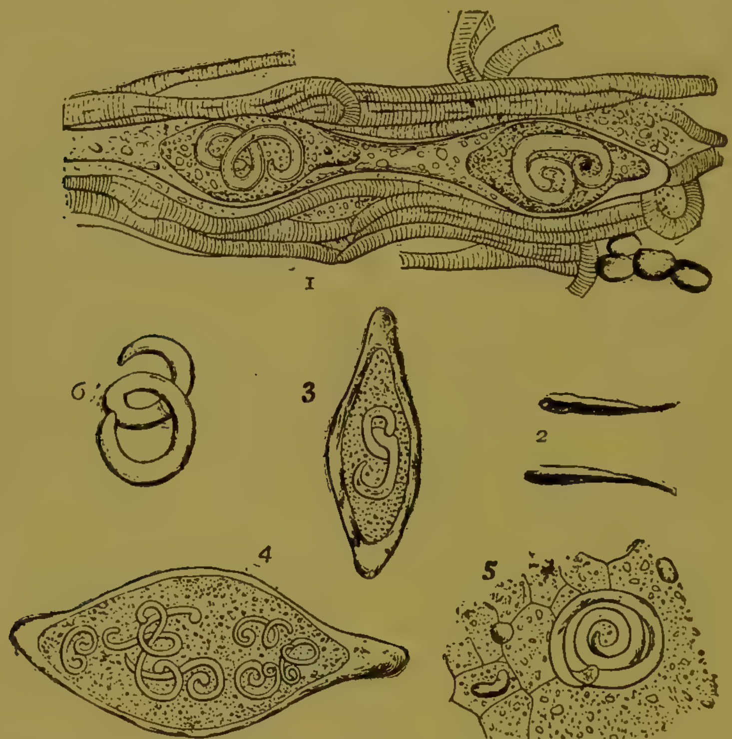

FIG. 55.—1, Trichinæ in muscle; 2, embryos; 3, encysted trichinæ; 4, cyst containing seven trichinæ; 5, trichina in fatty tissue; 6, trichina removed from cyst. (*Laveran.*)

Trichina spiralis is found almost exclusively in pork, occasionally in other mammals, especially the rat. It is a filiform worm, a millimeter long, coiled within a calcareous capsule 0.2–0.3 mm. in diameter (Fig. 55.) It infests chiefly the voluntary muscles, being more abundant near their tendinous extremities, and is generally visible to the naked eye as a small white speck, the coiled worm itself being easily revealed under a magnifying glass after treatment in a weak solution of caustic potash. Trichinosis in hogs is but too common all over the world, at least 2 per cent. being

thus affected in this country. When trichinous pork is eaten raw or imperfectly cooked, by man, the capsules are dissolved in the stomach and the worms liberated; in a few days they grow to full adult size and the females give birth to numerous embryos which at once migrate to all parts of the body. This migration is marked by fever, edema and intense muscular pain. The symptoms often suggest typhoid fever or acute tuberculosis. Death may occur within a few weeks, but generally the disease ends in recovery, the worms becoming encysted and incapable of further injury. Hogs are probably infected by eating meat wastes or excrements from trichinous animals.

Flukes.—Other meat parasites are the flukes found in the liver of cattle and sheep, producing the condition known as "rot." As this disease is not conveyed to man, the flesh of animals thus affected need not be condemned.

TRANSMISSION OF DISEASE BY MEAT.—According to Harrington, the cattle diseases in this country most common as causes of condemnation are tuberculosis, actinomycosis and anemia; next in order are septicemia, pneumonia, peritonitis, pyemia, icterus, abscesses and Texas fever.

Tuberculosis is one of the most common diseases of cattle, affecting also sheep and, to a lesser extent, swine. In Europe, from 10 to 40 per cent. of cows are tuberculous. In this country, the percentage seldom exceeds 2 or 3, while in the large abattoirs only about 1 in 2,000 cattle are found to be tuberculous (Harrington). The identity of the human and bovine bacilli has been generally accepted, and there is a strong presumption, if not convincing proof, that man may be infected by the meat or milk of tuberculous cows. The organs most frequently involved in animals are the liver, lungs, kidneys and brain, the muscles being very rarely affected. Whatever danger there may be from the consumption of meat of diseased animals is completely removed by cooking.

Actinomycosis, or "lumpy jaw," caused by the presence of a yellow ray-fungus, occurs in cattle and swine, and sometimes in man.

The meat of animals affected with anthrax should be condemned and destroyed, not only because of the difficulty of killing all the bacilli and spores by cooking, but also on account of the great danger of infection from handling it. The same remarks are applicable to the meat of glandered horses.

Poisoning by Meats.—Among the products of decomposition of proteids brought about by the action of bacteria, are various toxins and alkaloidal bodies called ptomains. Of the latter some are poisonous and many inert. The effects of these toxins and poisonous ptomains are

quite variable; some causing violent gastro-intestinal irritation while others act directly upon the heart or the nerve centers. They are often formed in decaying organic substances and are most virulent in the meat of animals affected with pyemia or septicemia, but may also be found in foodstuffs apparently wholesome. The meats most liable to cause poisoning are pork and veal and their preparations, especially if used raw or imperfectly cooked, or containing part of the entrails or viscera.

COOKING.

Cooking produces in foodstuffs certain important physical and chemical alterations, affecting their quality, digestibility, absorption and nutritiousness. It often improves their appearance and, at the same time, develops new and appetizing flavors. It destroys parasites and pathogenic germs, as well as the germs of putrefaction and those which bring about the production of ptomains. Its effect upon muscular fibers is to render them firmer and more brittle by the coagulation of albumen, and to separate them by the softening or gelatinizing of the connective tissue, thus greatly facilitating mastication. It diminishes the amount of water and removes more or less of the fat, salts and extractives. The digestibility of vegetable foodstuffs (some fruits excepted) is always much increased by cooking, but that of animal food is oftener decreased than improved. Thus raw beef disappears more rapidly from the stomach than when boiled or roasted; experience shows that raw or underdone meat is most suitable for delicate stomachs, provided it be chopped fine or scraped into a pulp and well seasoned.

All proteids coagulate at 170° F. or less; therefore, in cooking meat, it is unnecessary to go much beyond this point, except for a short time. The guiding rule in preparing animal and vegetable foods is to cook them slowly and at the lowest temperature that will accomplish the purpose. In cooking a piece of meat by any method (except when stewing or making broth), the first step is to subject it to a temperature high enough to speedily seal up the superficial layer by the coagulation of its albumen and thus prevent the loss of juice and soluble constituents. In *boiling*, the meat is plunged into boiling water and, after a few minutes, the water brought down to about 170°, at which temperature it is maintained at the rate of 15 minutes for each pound. If it be desired to prepare broth, a different process must be followed. In *broiling*, it is exposed to the direct heat of the fire which converts the surface extractives into new, savory substances. In *baking* (commonly miscalled roasting), it is placed in a hot oven, at 400° F., for a few moments, and then kept at a much lower

temperature at the rate of 15 minutes per pound, bearing in mind that the heat should be more moderate with a large joint than with a small one, to prevent burning. This is the most popular and satisfactory method of cooking. In *frying*, the meat, cut into small pieces, should be dropped and completely immersed in oil or fat heated to 400°, until little jets of smoke issue from them; if the temperature is not high enough, the pores of the meat not being immediately closed, it becomes impregnated with fat and indigestible. In *stewing*, it is cut into small pieces and placed in cold water which is heated slowly to 170° where it is maintained for several hours. All the extractives and other soluble substances are retained without loss.

Dressed meat, as usually issued to troops, contains about 15 per cent. of bone. Furthermore, in cooking, it loses from 25 to 30 per cent. of its weight, mostly from the evaporation of water, so that the quantity consumed is reduced in weight to about 60 per cent. of the raw material. To this, however, should be added the value of the juices utilized as gravy, broth, etc., and that of the bones which can be used for soup.

Good cooking is deemed so important in our Army that three "training schools for bakers and cooks" have been established by the War Department, one at Washington Barracks, D. C., another at Fort Riley, Kans., and the third at the Presidio, San Francisco, Cal., under the immediate charge of officers of the Subsistence Department. The classes under instruction are composed of specially selected men who manifest a desire to learn the trade of baker or cook and who show aptitude for the work. The course lasts four months and covers the management of messes, baking and cooking in garrison and the field.

BROTH AND MEAT EXTRACTS.

In preparing soup or broth, the object is to dissolve out as much of the constituents of the meat as possible. The meat should be cut into very small pieces and placed in cold water which is very slowly raised to the boiling point. In this way, the broth will contain the extractives and mineral matters, a small proportion of soluble proteids, a little fat and, if the boiling be prolonged, some gelatin; that is to say, all the savory and appetizing elements of the meat but hardly any of its nutritive principles. It stimulates the digestive functions, promotes the flow of gastric juice and prepares the way for more nourishing food; it is therefore a condiment and a stimulant. To make a beef tea really nutritious, the meat, after boiling, should be dried, pounded fine, screened and then added to the liquid extract.

Beef extracts are obtained by the action of hot water under pressure. They contain more soluble proteids than soups but, as only a small amount can be ingested without provoking gastro-intestinal disturbances, their value is practically about the same.

Beef juices are obtained from raw meats by high pressure, heat being avoided in order not to coagulate the proteids. In this way from 3 to 5 per cent. of assimilable proteids can be extracted, not nearly enough to supply the needs of the body.

PRESERVATION OF MEAT.

As meat must often be transported long distances, it is necessary to make it undergo certain preparations whereby it may be kept a variable period of time without decay or material loss of nutritive qualities. The methods of preservation mostly in use are refrigeration, canning, desiccation, salting and smoking.

Refrigeration.—Preservation by cold, whenever applicable, is generally preferred. Refrigerated meat may simply be chilled by exposure to a minimum temperature of 25° F. or else frozen throughout at a temperature of—8° or—10° F. In the first case it can only be kept one or two months, while, in the second case, it can be kept an indefinite time. Frozen meat, after being removed from the refrigerator, will remain sound as long as a week if protected from the sun and wrapped in non-conductive material. Such meat is wholesome, digestible and nutritive; it has nearly all the qualities of fresh meat and, when prepared from inspected animals, is often much better than the fresh beef from local markets. Freezing causes rupture of the muscle cells, so that in thawing there is more or less infiltration of the disintegrated tissues and free escape of the liquid contents, with loss of weight and some impairment of quality; for this reason thawed meat decays rapidly and should be used as soon as possible.

Canning.—Next to refrigeration, canning is the best method of meat preservation. Canned meat is largely used in our service as well as in foreign armies, on account of its very convenient shape for transportation and distribution. The cans being filled with the prepared meat and sealed, are plunged into boiling brine or superheated steam (about 260° F.) after making one or two punctures in the tops. The air being thus driven out, the punctures are closed with solder. On cooling, a vacuum forms in the can and the atmospheric pressure causes the top and bottom to fall in and present a concave appearance. Their bulging out, therefore, would

indicate decay and formation of gases. Freezing does likewise produce bulging, but without detriment to the qualities of the contents. Canned meat if prepared under proper inspection, as provided in our service, is perfectly wholesome; weight for weight it contains more nitrogenous matter than fresh meat and about the same quantity of fat, but has lost some of its extractives and is not as savory.

The canned meats issued by the Subsistence Department, all in key-opening lacquered cans, are corned beef, corned-beef hash, roast beef, roast-beef hash, beef and vegetable stew.

Corned beef is from the brisket, chuck and plate of the carcass, in two-pound net can, with not more than 1 ounce of clear jelly from soup stock. Chemically it contains 51.8 per cent. of water, 26.3 of protein and 18.7 of fat. Corned-beef hash consists of equal parts of vegetables (potatoes and onions) and meat, suitably seasoned with salt and pepper. Roast beef is also in two-pound net cans, with not more than 1/2 ounce of salt and 1 ounce of clear jelly made from soup stock. It contains about 59 per cent. of water, 26 of protein and 15 of fat. Roast-beef hash consists of equal parts of vegetables (potatoes and onions) and meat, suitably seasoned with salt and pepper, in 28 1/2-ounce net can. Beef and vegetable stew consists of 10 1/2 ounces of meat, 7 ounces of potatoes, 5 ounces of onion and 6 ounces of sauce, in 28 1/2-ounce net can.

Salting.—With rare exceptions, the only salt meats issued in our service are bacon and corned beef. Bacon, when properly cured and smoked, usually consists of 16.8 per cent. of water, 9.2 of protein and 61.8 of fat. It is appetizing and digestible when well cooked, and on account of its high calorific value particularly useful in cold countries. In warm countries it should be eaten sparingly, as a relish or for a change of diet, using the lean rather than the very fat and frying it until crisp and crackling.

Corned beef is prepared by pickling in a solution of salt, sugar, saltpeter and saleratus. It contains about 52 per cent. of water, 26 of protein and 19 of fat. As compared with fresh meat, it is more nutritive but less digestible, tougher and much too salty for prolonged use.

Desiccation.—This process was formerly extensively used in the West and Southwest or wherever the dryness of the air permits complete desiccation of thin strips of meat without putrefaction. Meat thus prepared, or "jerked," retains all its nutritive qualities. Pemmican consists of pounded jerked meat, mixed with fat and berries; it is a rich food furnishing the necessary energy for strenuous work on the frozen plains of the Northwest or in the Arctic Circle.

FISH, MOLLUSKS AND CRUSTACEANS.

Fish is a wholesome, nutritious and easily digested food. As compared with meat it contains more water, not quite so much protein and much less fat. A few species, such as salmon, turbot, eels, mackerel, lake trout and herring, contain 10 per cent. or more of fat, while the majority have less than 5 per cent. The popular belief that fish is better brain food than meat is without scientific foundation and not proved by experience. Fish is never improved by keeping, like meat; it decomposes quickly and should be eaten while fresh.

Mollusks, such as clams, oysters and mussles, contain a good percentage of proteids and a notable amount of carbohydrates, but are very poor in fat. They are very digestible, oysters somewhat more so than clams but less nutritious.

Mollusks, but especially oysters, have often been the vehicle of typhoid fever and may, in the same way, be that of other diseases. This happens when oyster beds are located near sewer outlets or in the way of currents from infected places, so that they become externally polluted. Oysters are also often transplanted to fresh water, near the shore, for fattening or storing purposes, where there may be great danger of infection. The germs of sewage are never found within the body of the mollusk, but adhering to the surface of the tissues and in the water within the shells. The danger is removed by placing the suspected oysters in pure sea water for one or two weeks, by washing them thoroughly before using, or else cooking them.

Crustaceans, such as lobster, crab, crawfish and shrimp, are richer in proteids than mollusks but less digestible and not suited to delicate stomachs.

MILK.

The composition of milk of average good quality, as given by Harrington, is as follows:

Fat (cream),	4.00 per cent.
Sugar,	5.00 per cent.
Proteids,	3.30 per cent.
Mineral matter,	0.70 per cent.
Total solids,	13.00 per cent.
Water,	87.00 per cent.

The fat exists in very minute globules which, rising to the surface, form the creamy layer. The last part of the milking ("strippings") is the rich-

est in fat. Casein constitutes the great bulk of the proteids; it contains sulphur and phosphorus, and is coagulated by heat in presence of lactic acid. The sugar, or lactose, is much less soluble than dextrose or cane sugar, and less sweet; through the action of certain bacteria it readily splits with formation of lactic acid. The mineral matter consists of phosphates and chlorides of potassium, sodium, calcium and magnesium. Potassium phosphate, indispensable for the growth and functions of muscles, is the most abundant, while calcium phosphate so necessary for the growth and repair of bony tissues, comes next in quantity.

Milk is an excellent food medium for bacteria which, under favorable conditions, multiply in it at the most amazing rate. Even with strict cleanliness, the milk as found in the pail a few hours after being drawn, generally contains thousands of them. Cleanliness and a temperature below 50° F. will keep them from increasing for a day or two, but under the ordinary conditions obtaining in dairies during the summer, Harrington found them to increase in 24 hours to 48,000 in a cubic centimeter, and to 680,000 in 48 hours. Milk, as sold in city shops, seldom shows less than 100,000 bacteria to the c.c. and often contains several millions. The effect of these swarming bacteria upon the health of the consumer is still a matter of conjecture. That they modify the quality of the milk and that some of them may render it unwholesome or even poisonous can be taken for granted. It is probable that the virulent ptomain *tyrotoxicon* which has been found in milk, cheese and ice cream, is due to bacterial action. On the other hand, may be considered beneficial those microbes which by their action upon the sugar of milk produce lactic acid and sour milk. Says Metchnikoff: "Among the useful bacteria, the place of honor should be reserved to the lactic bacilli. They produce lactic acid and thus prevent the development of butyric and putrefactive ferments, which are among our dangerous enemies." Sour milk, in various forms, whether naturally or artificially produced, is healthful and, for many stomachs, a better food than sweet milk.

To destroy bacteria or prevent their growth, milk may be sterilized or pasteurized. The complete sterilization of milk requires a temperature of 248° F., but this process, as well as ordinary boiling, changes the taste of the milk and impairs its nutritive qualities. For the destruction of disease-bearing bacteria, and the great bulk of the others, it is enough to pasteurize it, that is, to heat it to 155° F. for 20 minutes, and then cool it rapidly in ice to prevent the multiplication of the surviving bacteria before it reaches a safe minimum temperature.

Inasmuch as 99 per cent. of the bacteria are contained in the cream

layer of milk, it has been proposed that this layer be removed, subjected to sterilization and then replaced in the milk.

Butter is obtained by the churning of milk, and consists chiefly of the fat (cream), with salts, a little casein and lactose. It is one of the most acceptable and digestible of fats, and the usual accompaniment of our daily bread. Buttermilk, or the milk from which butter has been removed, has still decided food value, and its slight acidulous taste renders it refreshing, healthful and palatable to most persons. It shares the bactericidal properties attributed to sour milk by Metchnikoff.

Cheese consists essentially of the casein of milk. It is made by heating the milk to above 80° F. and then curdling it by rennet, sour whey, or by the acids formed by the lactic bacteria. After pressure to the proper consistence, the curd is allowed to ripen, when are produced the bacteria, moulds and ferments concerned in the development of special flavors. The composition of cheese is variable according to the milk used, and whether it is whole or skimmed. American cheeses of good quality contain about 36 parts of fat, 30 of proteids and 30 of water (Harrington). Cheese, therefore, is often much richer food than meat and consequently more difficult to digest. For habitual use it is only suitable for laborers or men doing hard physical work. In small quantity, the finer kinds make a delicious dessert on account of their savor and pungency.

Eggs.—The average composition of hens' eggs is: water 65.5, protein 12, fat 9.3, ash 1 (Langworthy). The white contains about 12 per cent. of protein but no fat. The yellow contains more protein and, besides, 33 per cent. of fat in emulsion, together with some sulphur and iron. Eggs are often better borne than meat and an excellent substitute for it, containing about the same percentage of nutritive matter, that is, less proteid but more fat, both in a very digestible form.

CHAPTER XV.

VEGETABLE FOODS.

Vegetable foods are characterized by the large proportion of carbohydrates which they contain, especially starch, but they also contain proteids and fats in variable proportions, thus furnishing, more completely than animal foods, all the principles needed by man for a normal and sufficient diet. Cooking is necessary for the digestion of most vegetables; it renders not only starch but also more or less cellulose amenable to the action of digestive juices.

Vegetable foods may be classified as follows:

1. Cereals.—Wheat, oats, rice, maize.
2. Pulses.—Beans, peas, lentils.
3. Tubers and roots.—Potatoes, carrots, turnips.
4. Green vegetables.—Cabbage, spinage, lettuce, onion.
5. Fruits used as vegetables.—Tomato, aguacate, cucumber, squash, pumpkin, egg plant.
6. Fruits and nuts.—Apple, peach, peanut, walnut.

The following table shows the composition of the vegetables most commonly used.

	Water	Proteids	Carbohydrates	Fat	Mineral matter	Authority
Wheat flour (high and medium grades)	12.	11.40	75.10	1.00	0.50	Atwater and Bryant.
Oatmeal	7.30	16.10	67.5	7.20	1.90	Bull. 28, Dept. Agric.
Cornmeal, unbolted	11.60	8.40	74.0	4.70	1.30	Bull. 28, Dept. Agric.
Cornmeal (bolted and germ removed)	12.57	7.13	78.36	1.33	0.61	Wiley.
Rice	12.40	7.50	78.80	0.40	0.50	Wiley.
Peas	14.99	22.85	52.36	1.79	2.58	König.
Kidney beans	13.74	23.21	53.67	2.14	3.55	König.
Lentils	12.34	25.70	53.46	1.87	3.04	König.
Potatoes	78.30	2.20	18.40	0.01	1.00	Atwater and Bryant.
Carrots	88.20	1.10	9.30	0.40	1.00	Atwater and Bryant.
Cabbage	91.50	1.60	5.60	0.30	1.00	Atwater and Bryant.
Tomatoes	94.30	0.90	3.90	0.40	0.50	Bull. 28, Dept. Agric.
Apples	84.60	0.40	14.20	0.50	3.00	Bull. 28, Dept. Agric.
Bananas	75.30	1.30	22.00	0.60	0.80	Bull. 28, Dept. Agric.
Peanuts (edible part)	9.20	25.80	24.40	38.60	2.00	Bull. 28, Dept. Agric.
Soft-shell walnuts (edible part)	2.50	16.60	16.10	63.40	1.40	Bull. 28, Dept. Agric.
Brazil nuts (edible part)	5.30	17.00	7.00	66.80	3.90	Bull. 28, Dept. Agric.

Wheat.—Wheat flour varies, not only according to the quality of the grain from which it is made but also according to the method of grinding the grain itself. The outer coverings, or bran layers, contain more of the proteids, fat and mineral matters than the white interior part. It follows that the whitest, high-grade flours are poorer in proteids, also slightly poorer in fat and salts, but correspondingly richer in starch, than the low-grade, colored flours. What they lose in nitrogen and other constituents, however, is more than made up by increased digestibility so that they should always be preferred to the so-called whole-wheat flour, except for special purposes. According to A. Girard, at least 30 per cent. of the wheat kernel (outer layers) should be removed by bolting to obtain the flour which will make the lightest and most porous bread, that is, the bread which is the most completely absorbed and utilized.

The proteids of wheat consist chiefly of gliadin and glutenin which, in contact with water, form gluten, the tenacious elastic substance which gives consistency to the dough and enables it to be baked into bread.

Bread.—To make ordinary fermented bread, the flour is mixed with warm water, salt and yeast (or leaven), then set in a warm place to ferment. The yeast acts upon the sugar, splitting it into alcohol and carbon dioxid; the latter, as it forms and expands, causes the dough to "rise" and to become spongy. If the fermentation proceeds too far, lactic and acetic acids may form in sufficient quantity to make the bread sour; if not far enough, the bread will be heavy and soggy. Heavy bread may also result from cheap flour poor in gluten, too much water, insufficient kneading of the dough and imperfect baking. The fermented dough, cut into loaves, is baked in an oven heated to about 480° F. In this process, the surface of dough is transformed into crust by desiccation and partial caramelization; the gases expand still more and the little cavities are further enlarged by the evaporation of the moisture; starch is rendered more soluble and some of the proteids converted into peptone-like bodies.

In non-fermented bread, the carbon dioxid is generated by "baking powders" consisting of sodium bicarbonate and an acid or acid salt, most commonly potassium bitartrate (cream of tartar), with enough starch to prevent these ingredients from reacting upon each other until dissolved in water. Again, the baking powder may be previously mixed with the flour as in the so-called self-raising flour; or the carbon dioxid may be evolved in the water used to make the dough, or otherwise forced through the latter. But the bread resulting from any of these artificial methods is distinctly inferior in taste and digestibility to fermented bread.

In the process of making dough, the flour absorbs 50 per cent. of its

weight of water, one-half of which evaporates in the oven, so that the added weight is about 25 per cent.; in other words, 100 pounds of flour should yield at least 125 pounds of bread.

The typical high-grade American bread, according to Wiley, consists of: water 35, proteids 8, carbohydrates 54.45, fat 0.75, ash 1.50. Bread, therefore, is somewhat deficient in proteids, much more so in fats and cannot be considered a perfect food; it must be supplemented with butter, cheese, bacon, or rich gravy. Well-made bread is highly nutritious and digestible, the total loss in the intestinal tract being less than 3 per cent.

Crackers, biscuits and hard-bread are made from unleavened or slightly leavened dough, with as little water as possible, and very little salt, slowly and carefully baked and afterward kept for some time in a heated room to complete desiccation. As they contain much less water than ordinary bread they are more nutritious and have greater keeping qualities but are also less palatable and digestible.

The French *pain de guerre*, the best hard-bread yet baked, can be kept sound and wholesome at least a year. It is made from an excellent quality of flour, bolted to 30 per cent., with yeast and salt, and therefore undergoes a certain degree of fermentation which makes it more appetizing and absorbent.

Fresh soft bread is, under all circumstances, the best of the components of the ration and should be furnished, even in the field, whenever possible; hard-bread is but a poor substitute. Experience has demonstrated that baking bread in camp is not attended with great difficulties. Each division in an army should have a baking detachment provided with a sufficient number of portable ovens, which establishes itself at some convenient central point in rear, or divides into brigade sections. Thus the Russian troops in Manchuria (1904 and 1905) were most of the time furnished with fresh bread, often baked only a few miles from their lines (see page 197).

Maize or corn, next to wheat, is our most important cereal. It is richer in fat than any other cereal excepting oats; much of this fat is in the germ which is often removed to prevent the meal from becoming rancid and mouldy. On account of its deficiency in gluten, corn cannot be made into fermented bread, but is consumed under various other forms and is always nutritious and wholesome.

Oats is the richest of cereals in proteids, fat and mineral matters. Oatmeal is mostly consumed in the form of cake and as porridge. It is highly nutritious but liable to produce acidity and disagree with many

persons. The large proportion of bran scales it contains gives it distinct laxative qualities. One advantage of oatmeat for soldiers in the field is the ease and quickness with which it is prepared; in the absence of fire it can even be eaten raw, after soaking in water.

Rice is the poorest of cereals in proteid and fat, but one of the richest in very digestible starch. It is the staple food of about one-third of the human race. In the absence of meat, rice should be supplemented with vegetables rich in proteids, such as beans and peas.

Pulses or Legumes.—The seeds of these plants are characterized by their richness in proteids, which equals or often exceeds that of meat. They also contain considerable potash and lime but are poor in fat and sodium chloride. The chief proteids are legumin and glutenin, forming what is commonly called vegetable casein. They are highly nutritious but of more difficult digestion than cereals or meats; under the most favorable conditions, from 15 to 20 per cent. of the proteids are unabsorbed and lost. It is therefore necessary to cook them thoroughly and with great care.

The ordinary pulses are beans, peas and lentils. The proteids of beans and peas contain sulphur, an ingredient which often gives rise to flatulency by the formation of hydrogen sulphide. Dry beans and peas should be soaked in warm water for 12 hours and then boiled several hours until perfectly done. The water must be soft, for the legumin forms insoluble compounds with lime; if hard, it should be previously boiled to precipitate the carbonates, or else have sodium carbonate added to it. Peas are best used ground, as meal, making palatable and very nourishing soup; they are a good occasional substitute for beans. Lentils are the best of the pulses and deserve to be better known and more generally used in this country. They contain even more proteids than beans and peas, and are free from sulphur; they are more digestible, more easily cooked and fully as well flavored.

Tubers and Roots.—The only true tubers used as food are the potato, the Jerusalem artichoke and arrowroot.

Potato is a wholesome and easily digested food but, on account of its very small content of proteids, an imperfect one. In the process of boiling it, more or less proteid and mineral matter are lost; comparatively little if boiled with the skin, but a great deal if it has been peeled, amounting to nearly one-half if, besides, it has been soaked in water. As the outside layers are driest, and consequently richest in starch and proteid, they must be saved as much as possible; to this end the skin is best removed automatically, by scraping, rather than by cutting. The juice

of the raw potato contains citric acid and citrates to which are due its well-known antiscorbutic properties.

Normally the potato contains only traces (mostly in the skin) of the narcotic poison, *solanin*, which exists more abundantly in many of the other plants of the same family (*Solanaceæ*). Under certain conditions, however, the amount of this poison in the potato increases to the extent of becoming dangerous; this may occur in potatoes that are young and immature, moldy or decayed, and always when sprouting. Therefore wholesome potatoes should be fairly well grown, sound and without any sign of germination.

FIG. 56.—Cells of a raw potato, with starch grains in natural condition. (*Munson.*)

Jerusalem artichoke (or tuberous sunflower), although of American origin, is but little cultivated in this country, and hardly anywhere for man's food.

Sweet potato is commonly cultivated in the Southern States for its valuable root which contains as much starch as the potato and a considerable amount of sugar besides.

Roots, such as carrot, beet, turnip, parsnip, oyster plant and radish, are watery and contain little nutritive substances, but they add variety and pleasant flavors to more substantial foods.

Green vegetables consist of the leaves and stems of various plants; as a class they contain somewhat less carbohydrates than roots and tubers but a little more proteid and salts; they are also valuable antiscorbutics; their appetizing flavors make them indispensable adjuvants to a well-ordered dietary, besides giving it bulk and promoting the action of sluggish bowels. Cabbage is not always easily

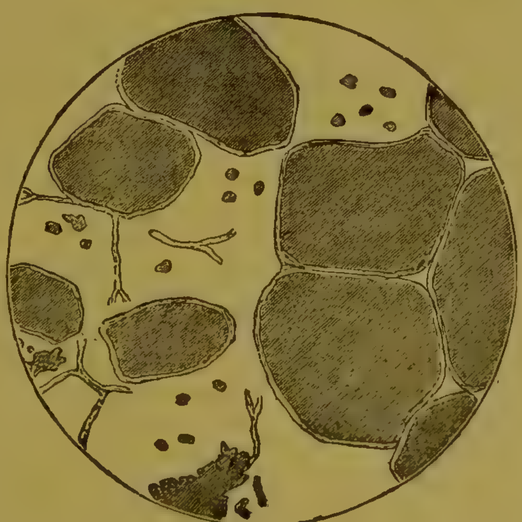

FIG. 57.—Cells of a thoroughly boiled potato. (*Munson.*)

digested; it contains sulphur which may produce flatulence. Lettuce and cresses are healthful and digestible. Celery and asparagus have useful diuretic properties. Onions are savory and wholesome, owing much of their value to a pungent oil containing sulphur. Vegetables such as celery, lettuce and all others eaten in salad and which, therefore, do not undergo the purification of fire, are liable to convey the eggs of parasites and pathogenic germs; they should always be carefully washed before being prepared for the table.

Fruits Used as Vegetables.—They include melon, cucumber, squash, pumpkin, egg-plant, tomato, etc., all very watery, the melon and tomato containing as much as 95 per cent. of water, but, nevertheless, useful, palatable and wholesome.

Fruits and Nuts.—Fruits, properly so-called, are mostly used in the raw state, as relish and dessert, for their pleasant acidulous taste. They may be divided into pulpous fruits (apples, peaches, cherries, plums, oranges, strawberries, etc.) and farinaceous fruits (chestnut, banana, bread-fruit, etc.). The former are very watery, containing sugar, acids, gum and pectin in variable proportions and having but little value as food; the latter contain a notable amount of starch and sugar and have decided nutritive value.

Nuts (see composition, page 181) are rich in proteids, carbohydrates and especially in fats; they constitute a highly nutritious food but greatly tax the digestive powers. As dessert they should be eaten sparingly.

CHAPTER XVI.

THE NUTRITIVE VALUE OF FOODS.

As already stated, we take food to repair the bodily tissues, as well as to evolve heat and the necessary energy for work. The capacity of any foodstuff to meet these demands can be determined, approximately, by ascertaining the amount of heat it will yield on complete combustion. It is possible, by laboratory experiment, to measure the exact amount of heat liberated by the burning of a definite weight of food in a calorimetric bomb, and this is assumed to represent the energy evolved by the oxidation of the same quantity in the system. This assumption is correct enough in the case of fats and carbohydrates which are completely consumed in the body to carbon dioxid and water, but needs qualification in the case of proteids which are only oxidized to urea, their final product of decomposition, so that their physiological value is about 25 per cent. less than their calorimetric value.

The potential energy of food as measured by the amount of heat obtained by combustion, is expressed in units of heat or *calories*. A calorie is the amount of heat required to raise 1 kilogram of water 1° C. (or one pound 4° F.). A "small calorie" is the amount required to raise one gram of water 1° C., so that there are one thousand small calories in the ordinary or large calorie. There are marked differences between the various proteids as regards their calorimetric or fuel value, animal proteids having a greater value than those of vegetable origin; the same difference exists between animal and vegetable fats, also in favor of the former. But, for practical purposes, the following averages of the calorimetric value of the three proximate pinciples of foodstuffs, as determined by Rubner, are generally accepted:

1 gram of proteid, = 4.1 calories.
1 gram of carbohydrates, = 4.1 calories.
1 gram of fat, = 9.3 calories.*

The unit of mechanical energy of food used in this country is the foot-ton, that is, the energy required to raise 2,240 pounds one foot. One

* According to Atwater, the latest and most reliable researches give the following averages: protein, 4 calories; carbohydrates, 4 calories; fats, 8.9 calories; but they take into account only the material which is digested and oxidized and actually available for the body.

calorie is equal to 1.53 foot-tons. Therefore we assume that one gram of fat, oxidized in the body, evolves sufficient heat to warm 9.3 kilos of water 1° C., or sufficient mechanical energy to raise 14.2 tons one foot. Expressed according to the metrical system, one calorie is equivalent to 425.5 kilogram-meters, that is, the energy required to raise 425.5 kilograms one meter.

AMOUNT OF FOOD NECESSARY.

According to the generally accepted standard of Carl Voit, a man of average weight (70 kilos or 154 pounds), doing moderate work, needs 118 grams of proteid,* 500 grams of carbohydrate and 56 grams of fat, with total fuel value of 3,055 calories. This was found to be the average food consumption of laboring men in Germany. German soldiers in active service, says Voit, eat 145 grams of proteid, 500 of carbohydrate and 100 of fat, with fuel value of 3,574 calories. In France, according to Gautier, the ordinary laborer must have 135 grams of proteid, 700 of carbohydrate and 90 of fat, with fuel value of 4,260 calories. In England, weavers were found to take 151 grams of proteid, with enough fat and carbohydrates to make a total fuel value of 3,475. In the United States, according to Atwater, a man doing moderately active muscular work consumes 125 grams of proteid, with enough fat and carbohydrates to make a total fuel value of 3,400 calories, while when doing hard muscular work the proteid is increased to 150 grams and the fuel value to 4,150 calories. The dietary of the Yale University crew, at Gales Ferry, averaged: 171 grams of proteid, 171 of fat and 434 of carbohydrates, with fuel value of 4,070 calories; that of Harvard University crew averaged 160 grams of proteid, 170 of fat and 448 of carbohydrates, with fuel value of 4,074 calories (Chittenden).

Langworthy, of the United States Department of Agriculture, appears to have reached conclusions somewhat at variance with those of the preceding observers; he says: "In the average of a large number of dietary studies with men at moderately active muscular work, the quantity of protein in the food actually eaten is between 100 and 105 grams per day."

For the healthiest condition of the body and the greatest development of energy, the three proximate principles must be present and combined in suitable proportions; neither proteids nor carbohydrates alone could supply the necessary nutriment; fats, on the other hand, can only be di-

*One pound of proteid is contained in 6.4 pounds of beef sirloin.

gested and absorbed in relatively small quantity, while neither carbohydrates nor fats can perform the essential functions of proteids; furthermore, the digestive fluids are obviously intended to act upon mixed and varied foods. The relative proportion of these food constituents, in well ordered dietaries, is generally set down in round numbers, as one part of proteid, half a part of fat and four parts of carbohydrates, the proportion of nitrogen to carbon being 1 to 16 or 18. The amount of proteid should not fall below 1.69 grams according to Voit, or one gram, according to Lapicque, for each kilo of body weight. This amount varies only within narrow limits; when more energy is required for an increase of muscular work, it is supplied by carbohydrates and fats, especially the latter which possess the highest fuel value. Fat is therefore the element of the dietary which oscillates most, in accordance with the amount of work performed and the temperature of the air.

The amount of food stated above as necessary, is based entirely upon the assumption that whatever is habitually consumed by a class of men, is a correct basis upon which to determine the actual amount required by such men. But it is obvious that such an assumption does not rest upon scientific grounds and is liable to lead into serious errors.

The ideal diet.—Any excess over what is really necessary to meet the wants of the body is certainly useless and may be harmful. It should always be remembered, says Atwater, that "the ideal diet is that combination of foods which, while imposing the least burden on the body, supplies it with exactly sufficient material to meet its wants." According to Prof. R. H. Chittenden, who has devoted much careful study to this question, the ideal diet is the smallest amount of proteids, fats and carbohydrates: "sufficient to establish and maintain physiological and nitrogen equilibrium, sufficient to keep up that strength of body and mind that is essential to good health, to maintain the highest degree of physical and mental activity with the smallest amount of friction and the least expenditure of energy, and to preserve and heighten, if possible, the ordinary resistance of the body to disease germs." To determine this ideal diet, habits are untrustworthy. The fact that they are shared by many individuals, or a whole nation, does not prove that they are correct and hygienic. The extent to which we indulge our cravings for food is not a measure of the extent to which it is best to carry such indulgence. In many communities, a large proportion of the men drink and smoke immoderately without any apparent harm, yet no one will contend that such habits respond to any actual need of the body economy, subserve any useful purpose or are innocuous. To overeat is one of the habits most

easily contracted, often long tolerated by the system without obvious protest, and always most difficult to correct. It is probably the origin of many of the diseases of modern civilized society, and therefore no question, within the whole field of preventive hygiene, seems more worthy of careful attention than the exact determination of suitable dietaries for all conditions.

The food constituent which is most commonly eaten in excess is the proteid. Meat, under its many forms, is appetizing and savory, and almost always an important part of the diet of people who can afford it. But, being expensive, we find it used much more abundantly by prosperous and rich nations than among poor ones, the latter being often, from necessity, reduced to an entirely vegetable diet. The assertion, sometimes made, that the most civilized nations have reached their present intellectual standard because of their high consumption of meat is an absurd confusion of cause and effect.

Prof. Chittenden's Experiments.*—In 1902, Prof. Chittenden began a series of experiments to determine, on scientific grounds, the amount of proteids necessary to maintain the best physical condition of the adult body. During the course of several years, he experimented with groups of professional men, athletes and soldiers, gradually and steadily reducing their proteid food, and in all cases with the same striking and convincing result, namely, that the proteid constituent advocated by Voit and others is much too high, at least twice greater than actually necessary. He found, by multiplied demonstrations, that the so-called nitrogen equilibrium, that is, the condition of the active body in which the ingestion and excretion of nitrogen balance each other, without loss of body weight, can be easily maintained with a daily intake of 0.85 gram of proteid per kilo of body-weight, and that any quantity in excess of this is wasted if not harmful. He concluded that the proper diet for a man weighing 70 kilos (154 pounds) should not exceed 60 grams of proteid, with enough fat and carbohydrates to make up a total fuel value not exceeding 2,800 calories.

The 13 soldiers experimented upon by Prof. Chittenden, during a period of six months, were fed upon this reduced diet which, however, within the terms stated, admitted of many varied combinations. They led an active life, performing each day a certain amount of prescribed exercise in the gymnasium in addition to their regular drill and ordinary duties. Their weight remained practically the same, several losing one or two pounds during the first few weeks and their weight remaining station-

*Physiological economy in nutrition, by Russel H. Chittenden, 1904.

ary thereafter. At the end of the experiment, they were in the best of health, *having all gained materially in strength and endurance*, as ascertained by careful tests in the gymnasium.

It is well known that the amount of nitrogen excreted rises and falls with the amount ingested and is directly proportional to it, which shows that there is no appreciable storing of it even when the intake is very much increased; only a very small proportion becomes transformed into living organized tissue, most of it, while still circulating in the fluids of the body, being metabolized into urea and thrown out as of little or no value. The greater energy needed for hard or violent muscular work is best obtained from an increased quantity of fats and carbohydrates, and so long as these principles are freely supplied there will be no loss of muscular tissue, even though the proteid of the food remains unchanged.

Food which contains more proteids than the body requires is not only wasted but there is every reason to believe that it is positively dangerous. The many decomposition products resulting from the breaking down of the circulating unorganized nitrogenous material crowd the blood, lymph and tissues; it is believed that they impair the phagocytic function of the white blood-corpuscles, that is, their power to ingest and destroy the pathogenic bacteria which invade the system; it is also probable they that exert an inhibiting effect upon the peripheral endings of the motor nerves or upon the muscle fibers themselves, thus impairing the functional power of the tissues, causing fatigue to be readily felt after exertion and loss of the power of endurance.

We know that gout often follows, or is aggravated by a free meat diet, doubtless the result of a failure of the nitrogenous decomposition products, when in excess, to be properly oxidized and eliminated.

A consumption of proteid food much beyond physiological needs means a large amount of urea and uric acid which must be passed out through the kidneys, thus throwing a constant strain upon those organs, particularly dangerous when they are already the seat of inflammation and degeneration, as in Bright's disease.

Again, we know that many symptoms of toxemia, or self-poisoning, result from absorption, into the blood, of anaërobic putrefactive bacteria from the large intestines. In view of the fact that these bacteria, according to Dr. C. A. Herter, are always more abundant in the intestinal tract of carnivorous than of herbivorous animals, it seems quite probable that a free meat diet promotes their multiplication.

Conclusions.—From the results reached by Chittenden and other experimenters, and from the above considerations, we are irresistibly

led to the conclusion that the standard diet of Voit, and other physiologists, must be modified so as to average about as follows:

Quantity		Calories
Proteid	60 grams	246
Fat	60 grams	558
Carbohydrates	500 grams	2050
		Total, 2854

Sixty grams of proteid are contained in one-half pound of fresh lean beef; but as milk and eggs, as well as all vegetable foodstuffs contain nitrogen, they will necessarily contribute a large part of the required proteid, seldom less than one-half, so that the amount to be supplied in the form of flesh (meat, poultry, fish) will seldom exceed 30 grams (one ounce), contained in a quarter pound of boneless, fresh, lean beef. Thus Prof. Irving Fisher, of Yale, has shown by experiment upon students, that the highest degree of endurance was reached at the close of a period of five months, upon a diet which, beginning with a daily average of 52 grams of proteid from flesh foods, and total fuel value of 2,830 calories, was reduced to about 8 grams from flesh foods, with total fuel value of 2,220 calories.

This subject is further considered in connection with the chapter on *Rations*.

CHAPTER XVII.

FIELD COOKERY.

This very important subject has not yet received the study which it deserves nor reached the development of which it is capable. Under field conditions the cooking outfit should be as light and simple as possible, but experience has shown that, even then, it is generally practicable to provide each company with a few utensils, carried by pack animals or wheeled transport, which will greatly contribute to the comfort of the men and the improved quality of their food.

In the absence of field ranges, the most easily improvised kitchen consists of a trench 4 feet long, dug in the direction of the wind, with chimney at the leeward end, one or two feet high, built of sod, stone or mud; the trench should be a foot deep, well open at the windward end, where

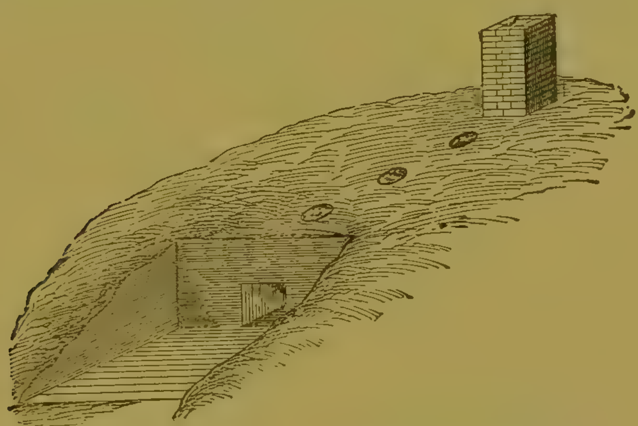

FIG. 58.—Excavated fire-place in side of bank.

the fire is made, and shallow up under the chimney, its width being 2 inches less then that of the kettles; if material is at hand, it can be closed above so as to make a regular flue, leaving two or three openings for the kettles. As the wind changes, another trench is dug accordingly, leading under the same chimney. Several trenches may thus radiate from the same chimney, those not in use being temporarily clogged up. If time permits, a crane can be put up, consisting of a pole supported on two forked uprights, or of an iron crossbar with hooks for hanging the pots.

In clayey soil, an underground horizontal flue, one foot square, is dug

in the side of a bank, one foot from the surface of the ground, and its internal end connected with a chimney. Along its course, openings are made in which to place the kettles (Fig. 58).

In the field, the mess furniture of the American soldier consists of a cup, knife, fork, spoon and meat can, all carried in the haversack. The cup is of aluminum with slot in handle into which can be inserted the flattened end of a stick, to place it on and take it off the fire.

The device for individual cooking, or "meat can", consists of a dish and a plate of block tin, which fit together. To the dish is attached a light

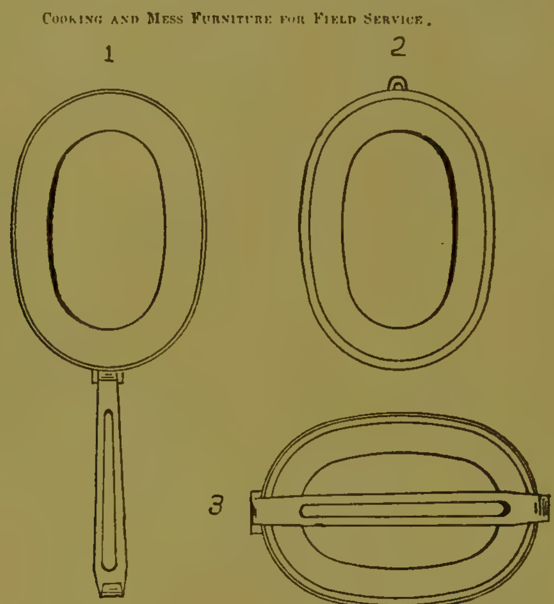

Fig. 59.—Meat can. 1, Body with handle; 2, cover; 3, meat can closed

hinged handle which, when both parts are assembled, folds over the plate, holding it firmly in place. The dish is used for soup or porridge, as frying pan, to warm up cold food, etc. (Fig. 59).

To each company in the field, the Subsistence Department supplies a steel range 36 inches long, 20 high and 23 wide, weighing when packed, complete, with utensils, 350 pounds, the weight of the utensils being 70 pounds (Figs. 60, 61).

Fireless Cooker.—Any cooking device saving fuel and time is worthy of consideration in the field and, on that account, much attention has been given, of late years, to the so-called self-cooking stove or fireless cooker. It consists of a strong box closing tightly and containing vessels in which the articles of food, partly cooked, are placed. The vessels fit snugly in the box and are surrounded on all sides by a thick layer of some non-

conductive substance. The food prepared in the ordinary way and placed in the vessels is boiled or otherwise cooked for a short time (20 to 30 minutes) in a range or over a fire, and the vessels, securely clamped down,

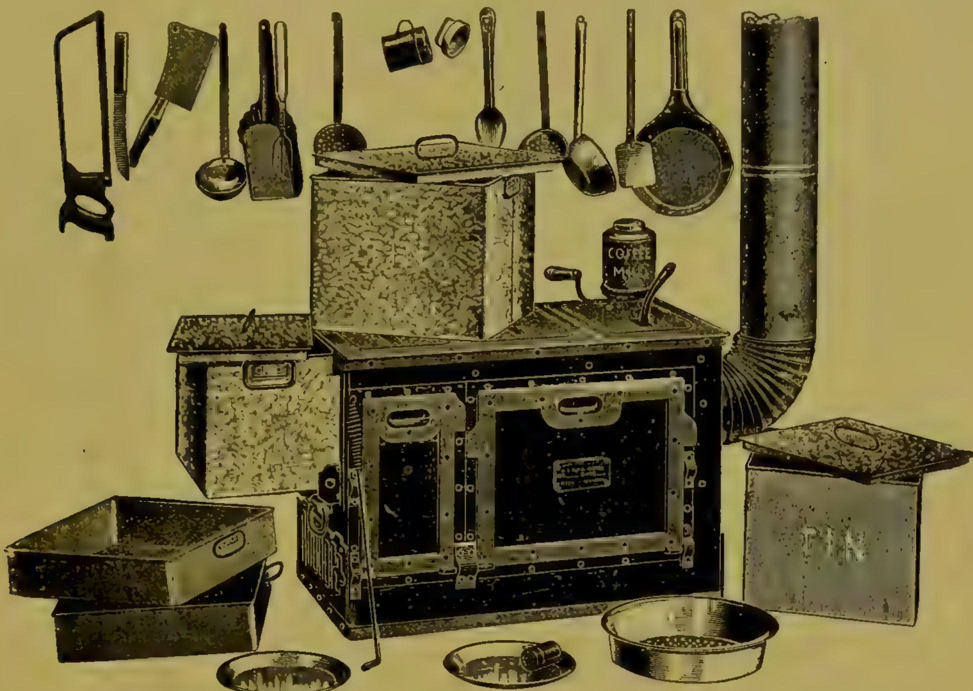

FIG. 60.—Army field range, with utensils.

FIG. 61.—Army field range packed for transportation.

are returned to the box. The outside atmosphere being unable to reach them, their temperature is not sensibly lowered and the food continues to cook until it is thoroughly and evenly done, requiring about twice the time that would be taken in an ordinary stove. A longer stay in the

cooker is said not to be detrimental to the quality of the food inasmuch as there is no loss by evaporation. The fireless cooker with which the Subsistence Department has been experimenting contains 2 kettles, of a capacity of 9 gallons; each contains a roaster, but when used for stewing or boiling the roaster is removed. Two such cookers are designed for each company. The outfit, complete, weighs 400 pounds, and 625 pounds with all vessels filled (Fig. 62).

FIG. 62.—Fireless cooker with two kettles.

This system of cooking possesses advantages for the field; it greatly economizes fuel and gives the men a well-cooked meal on their arrival in camp. Where wood cannot be procured it might be exceedingly valuable. On the other hand, it requires a heavy and unwieldly apparatus which does not take the place of the field range but only supplements it, thus adding materially to the weight of the company baggage. On this account the general opinion of competent observers is adverse to its use for military purposes.

Baking Ovens.—Field ovens for baking bread can be readily improvised; an excavation in a steep bank, with the end tapped for a flue, would first suggest itself. Dutch ovens are also convenient for the purpose. Portable ovens should be provided whenever practicable; in our

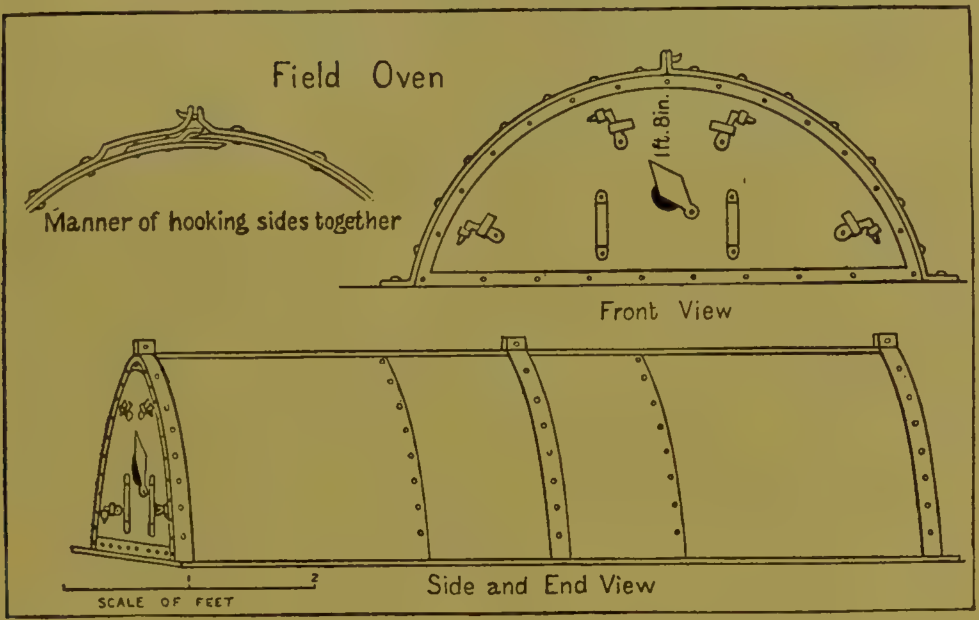

FIG 63.—Field oven for baking bread.

Army, the field oven is made of two pieces of sheet iron, so curved that when their upper edges are connected and the lower edges fixed in the ground, they form an arch 5 feet long, 3 feet 9 inches wide, and 1 foot 4

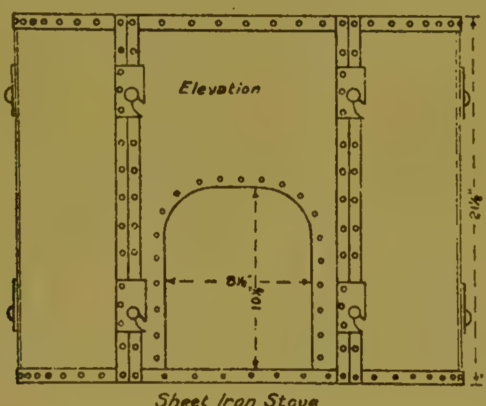

FIG. 64.—Japanese field cooking stove. (*Kuhn.*)

inches high; the front is closed by a two-handled iron door and the rear by a plate; when set up, the whole, excepting the door, is covered with a layer of earth; the door serves both as draft and vent for the smoke. Such an oven, if kept in constant operation for 24 hours, can bake enough

bread for 1,000 men. A larger size is also supplied, 6 feet long and 4 feet wide, formed of three pieces of sheet iron; it is operated in the same manner. (Fig. 63.)

A much larger and promising field baking oven, is that lately devised by Major Hart of the Subsistence Department. It is a square structure of steel, readily knocked down for transportation, and which, when set up, can accommodate three tiers of pans. Its base is banked around with earth, and the fire made in a pit underneath. The walls are triple, with two spaces between them; through the inner space pass the flames and smoke of the fire so that the four faces of the oven are bathed in heat; the second or outer space is filled with sand to prevent loss of heat; the top is likewise covered with sand. This oven has the great merit of a large output with comparatively little fuel.

FIELD COOKING OF FOREIGN ARMIES.

For cooking in the field, the English, German and French troops are left entirely dependent upon what they carry on their persons. France

FIG. 65.—Japanese field company kitchen. (*Kuhn.*)

and Germany have recognized the advantages of the Russian ambulant kitchen and are conducting experiments which may lead to its adoption after such modifications as may be found necessary.

The Japanese field cooking outfit consists of a stove or segmented

FIG. 66—Japanese field stoves and kettles packed on regulation saddle. (*Lynch.*)

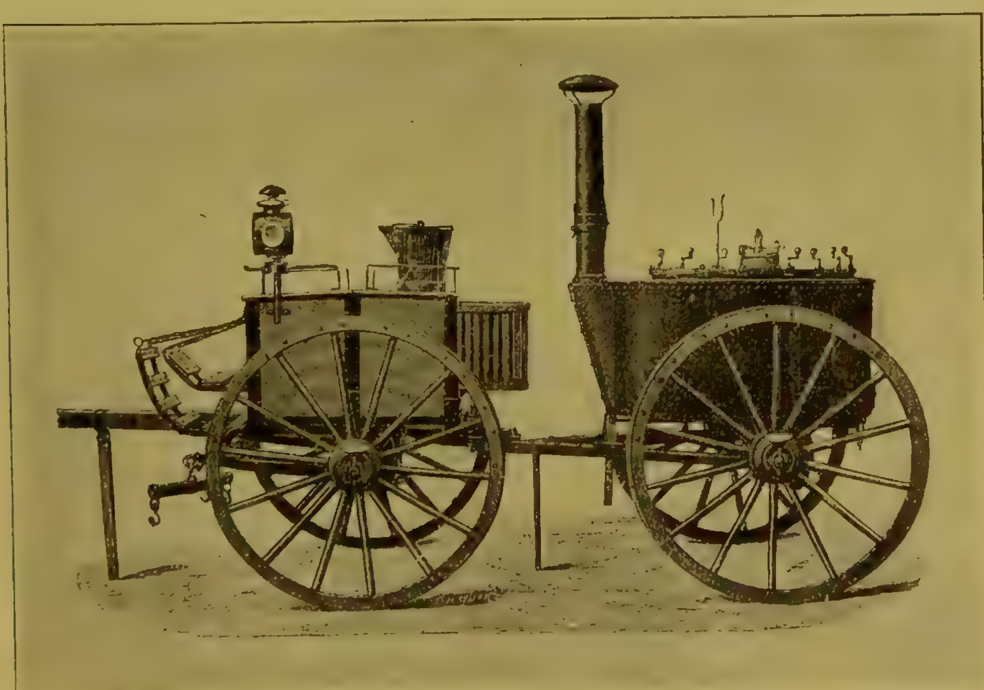

FIG. 67.—Russian wheeled kitchen for a company of infantry in the field.

cylinder of sheet iron, 22 inches in diameter, without top or bottom (Fig. 64); of a thin cast iron kettle which fits into the stove; of the rice boiler or colander which rests by handle lugs on the rim of the kettle; and of various cans and small utensils. Four cooking outfits are allowed for a company of 235 men (Fig. 65). They are transported on pack animals, each stove knocked down into six segments (Fig. 66). Such outfit is specially adapted to a ration consisting chiefly of rice. The individual

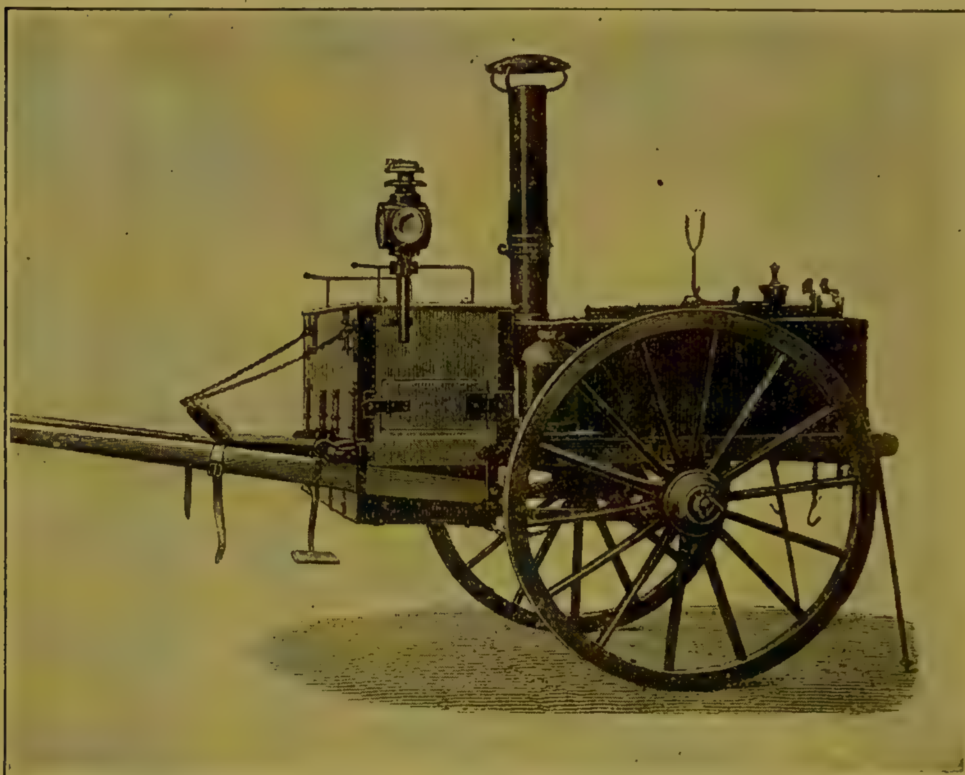

FIG. 68.—Russian wheeled kitchen for a company of cavalry in the field.

mess-can of the Japanese soldier contains several compartments for pickles, vegetables and sauces, and is also used to cook rice (Kuhn).

The Russian cooking outfit is by far the best as yet devised, having successfully stood the test of hard campaigns. It is practically an ambulant kitchen mounted on wheels. Two sizes are used, the larger for an infantry company of 240 men, on four wheels drawn by two horses (Fig. 67), and the smaller for a cavalry troop of 120 men, on two wheels drawn by one horse (Fig. 68). The cooking proceeds while on the march so that, on getting into camp, the men do not have to wait for their meal. Two types were used by the Russian troops in Manchuria, one devised by

Colonel Braün and the other by Colonel Debronrawoff. The Braün type, which was by far the most common, consists essentially of a boiler, with fire-box and chimney. The boiler is double, the inner wall of copper tinned inside, the outer of iron lined with asbestos. The lid can be screwed down air-tight so that the contents are cooked under considerable pressure, the danger of explosion being prevented by a safety valve. A perforated aluminum bottom, for cooking grits or cereals, can be placed in the boiler. This type therefore admits only of boiling and steaming, which is not much of an objection in the case of the Russian soldier ac-

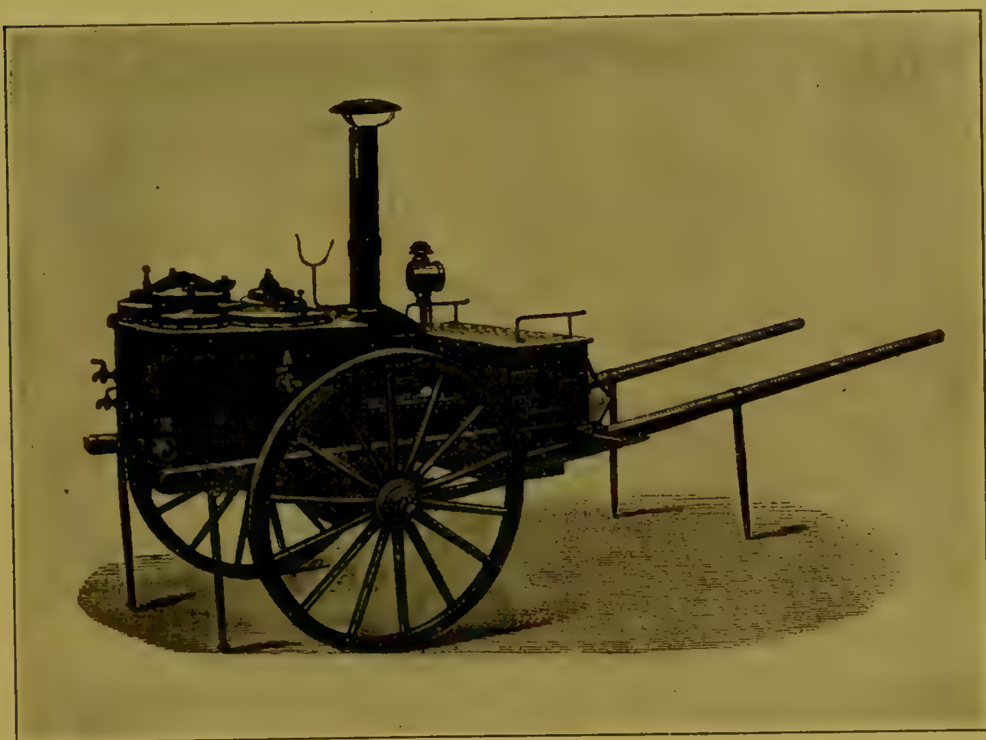

FIG. 69.—Russian wheeled kitchen for officers in the field.

customed to soup and boiled meat. For officers, a special form is constructed which admits of boiling, steaming and roasting (Fig. 69). The Debronrawoff type is somewhat more complex but equally strong and practical, admitting of boiling, roasting and stewing.

The Russian system fs ideal in principle and, with a few modifications, could be readily adapted to our service; not only would it supply varied and well-cooked food with least trouble and when most needed, but also sterilized water. The chief objection against it is the additional transportation involved, namely one horse or mule per company. It must be

remembered, however, that the one wagon allowed each company to carry all its baggage and supplies, will often be overloaded or insufficient, and that the ambulant kitchen would be the easiest and most effective method of relief.

In the Norwegian service, a cooking outfit mounted on wheels has also been tried, but instead of kettle and fire-box, a fireless cooker is used, a system, for reasons already stated, deemed unsatisfactory.

CHAPTER XVIII.

THE RATION.

"A ration is the allowance for the subsistence of one person for one day and varies in components according to the station of the troops or the nature of the duty performed, being severally known as the garrison ration, the field ration, the haversack ration, the travel ration, the Filipino ration and the emergency ration."

I. Garrison Ration.

Issued to troops in garrison, in permanent camps and during maneuvers, being the same in our colonies as in the United States. It is as follows:

Component articles and quantities		Substitutive articles and quantities in ounces	
Beef, fresh	20 oz.	Mutton, fresh	20
		Bacon[1]	12
		Canned meat, when impracticable to furnish fresh meat	16
		Hash, corned beef, when impracticable to furnish fresh meat	16
		Fish, dried	14
		Fish, pickled	18
		Fish, canned	16
		Chicken or turkey, dressed, on national holidays when practicable	16
Flour	18 oz.	Soft bread	18
		Hard bread, to be ordered issued only when impracticable to use flour or soft bread	16
		Corn meal	20
Baking powder	.08 oz		
Beans	2.4 oz.	Rice	1.6
		Hominy	1.6
Potatoes[2]	20 oz.	Potatoes, canned	15
		Onions, in lieu of an equal quantity of potatoes, but not exceeding 20 per centum of total issue.	
		Tomatoes, canned, in lieu of an equal quantity of potatoes, but not exceeding 20 per centum of total issue.	
		Other fresh vegetables (not canned) when they can be obtained in the vicinity or transported in a wholesome condition from a distance, in lieu of an equal quantity of potatoes, but not exceeding 30 per centum of total issue.	
Prunes[3]	1.28 oz.	Apples, dried or evaporated	1.28
		Peaches, dried or evaporated	1.28
		Jam, in lieu of an equal quantity of prunes, but not exceeding 50 per centum of total issue.	
Coffee, roasted and ground	1.12 oz.	Coffee, roasted, not ground	1.12
		Coffee, green	1.4
		Tea, black or green	.32
Sugar	3.2 oz.		
Milk, evaporated, unsweetened	.5 oz.		
Vinegar	.16 gill	Pickles, cucumber, in lieu of an equal quantity of vinegar, bnt not exceeding 50 per centum of total issue.	

Component articles and quantities		Substitutive articles and qauntities in ounces	
Salt	.64 oz.		
Pepper, black	.04 oz.		
Cinnamon	.014 oz.	Cloves	.014
		Ginger	.014
		Nutmeg	.014
Lard	.64 oz.		
Butter	.5 oz.	Oleomargarine	.5
Sirup	.32 gill		
Flavoring extract, lemon	.014 oz.	Vanilla	.014

[1]In Alaska, 16 ounces bacon or, when desired, 16 ounces salt pork, or 22 ounces salt beef.
[2]In Alaska the allowance of fresh vegetables will be 24 ounces instead of 20 ounces, or canned potatoes, 18 ounces instead of 15 ounces.
[3]At least 30 per centum of the issue to be prunes when practicable.
NOTE.—Food for troops traveling on U. S. Army transports will be prepared from the articles of subsistence stores which compose the ration for troops in garrison, varied by the substitution of other articles of authorized subsistence stores, the total cost of the food consumed not to exceed 24 cents per man per day.

"The usual ration of bread is eighteen ounces, but the weight of it may be increased within the limits of the flour ration, at the discretion of the commanding officer, upon the recommendation of the post council of administration. Such portion of the flour as the company commander deems necessary for food in other forms than bread—not exceeding two ounces for each ration—may be drawn by the company. The remainder will be turned in to the post bakery, and for each ration of flour thus turned in, the company is entitled to one ration of bread or the price of one flour ration. Savings on the flour ration, ordinarily thirty-three per centum, will be disposed of by the post treasurer for the benefit of the troops."

The fuel value, in calories, of the principal components is as follows:

Component articles	Quantity in ounces	Fuel value
Fresh beef	20	1287
Fresh mutton	20	1440
Bacon	12	2040
Dried fish	14	276
Pickled fish	18	1029
Canned fish	16	680
Flour	18	1828
Soft bread	18	1355
Hard bread	16	1712
Corn meal	20	1986
Beans	2.4	228
Rice	1.6	160
Hominy	1.6	172
Potatoes	20	368
Sugar	3.2	350
Lard	0.64	160
Butter	0.5	106
Sirup	1.3	192

The garrison ration, as may be seen, admits of many combinations which insure variety. It is comprehensive and elastic and can be adjusted to any climate. By selecting the most nutritive articles, such as bacon, hard bread or cormeal, beans, potatoes, dried fruit, butter and sirup, we can obtain from it a maximum fuel value of 5,378 colories according to Langworthy or 5,674 calories according to Wiley. On the other hand, by using such articles as dried fish, soft bread, rice, potatoes, canned tomatoes and dried fruit, the fuel value can be reduced to 2,500 calories. The average garrison ration, habitually consisting of fresh beef, soft bread, beans, potatoes and onions, dried fruit, butter, sirup and sugar (or their nutritive equivalents), weights 65 ounces and contains 99 grams of fat, 481 of carbohydrates and 157 of proteids, with total fuel value of 3,536 calories.

The garrison ration is often supplemented by articles obtained from the post garden or purchased from the company fund, and which largely contribute to give it variety and appetizing value. The company fund is made up chiefly from the savings of the ration, and dividends from the post exchange (canteen) and post bakery.

"All articles of the garrison, travel, or Filipino ration due to a company, bakery, or other military organization, and not needed for consumption, will be retained for reissue by the commissary and will be paid for by him as savings, at the current prices of the component articles of the ration, and not in any instance at prices of substitutive articles, the use of the latter being limited to issue in kind where economy and a due regard to the health and comfort of the troops may so require. No savings will be allowed to troops on United States Army transports. The making of savings with a view to purchasing elsewhere any article of the ration carried in the commissary is strictly prohibited" (A. R. 1246).

Fresh meats are ordinarily issued seven days in ten, and bacon three days.

The ration of enlisted men sick in hospital, and of female nurses while on duty in hospital, is commuted at the rate of 30 cents per ration, except that at the general hospital at Fort Bayard, N. M., 50 cents per ration is authorized for enlisted patients therein.

Ice.—Ice is issued by the subsistence department to organizations of enlisted men as follows: For each ration, 4 pounds, the maximum allowance to any organization or detachment of less than 100 men to be 100 pounds a day, and to organizations of 100 men or more to be 1 pound a day, per man. No allowance of ice is made to troops stationed north of the 43d parallel, except in the States of Washington, Oregon and

Idaho, where the full allowance may be issued, beginning April 16 and ending October 15, and during the remaining six months one-half of such allowance may be issued. To troops stationed between the 37th and 43d parallels the allowance is for six months only, beginning April 16th and ending October 15, except that in the State of California the full allowance may be issued for the entire year. To troops stationed south of the 37th parallel the full allowance may be issued for the entire year.

II. Field Ration.

Issued to troops not in garrison or permanent camps.

Component articles and quantities		Substitutive articles and quantities in ounces	
Beef, fresh, when procurable locally	20 oz.	Mutton, fresh, when procurable locally	20
		Canned meat	16
		Bacon	12
		Hash, corned beef	16
Flour	18 oz.	Soft bread	18
		Hard bread	16
Baking powder, when ovens are not available	.64 oz.		
Yeast, dried or compressed, when ovens are available	.04 oz.		
Beans	2.4 oz.	Rice	1.6
Potatoes, when procurable locally	16 oz.	Potatoes, canned	12
		Onions, when procurable locally, in lieu of an equal quantity of potatoes, but not exceeding 20 per centum of total issue.	
		Tomatoes, canned, in lieu of an equal quantity of potatoes, but not exceeding 20 per centum of total issue.	
Jam	1.4 oz.		
Coffee, roasted and ground	1.12 oz.	Tea, black or green	.32
Sugar	3.2 oz.		
Milk, evaporated, unsweetened	.5 oz.		
Vinegar	.16 gill	Pickles, cucumber, in lieu of an equal quantity of vinegar, but not exceeding 50 per centum of total issue.	
Salt	.64 oz.		
Pepper, black	.04 oz.		

III. Haversack Ration.

Issued to troops in the field in active campaign when transportation is limited.

Component articles and quantities in ounces	
Bacon	12
Hard bread	16
Coffee, roasted and ground	1.12
Sugar	2.4
Salt	.16
Pepper, black	.02

These articles contain about 218 grams of fats, 489 of carbohydrates and 113 of proteids, with total fuel value of 4,448 calories.

The hard bread, coffee, sugar, salt and pepper are separately wrapped up in impervious paraffin paper, and the bacon contained in a tin can.

Existing orders prescribe that one day in each alternate month of the season of practical instruction, not exceeding three days in each year, the use of haversack ration, with individual cooking, will be required by all troops in the field for purposes of instruction.

IV. Travel (or Cooked) Ration.

Issued to troops traveling otherwise than by marching, and separated from cooking facilities.

Component articles and quantities in ounces.			
Soft bread	18	or Hard bread	16
Beef, corned	12	or Hash, corned beef	12
Beans, baked	4		
Tomatoes, canned	8		
Jam	1.4		
Coffee, roasted and ground	1.12		
Sugar	2.4		
Milk, evaporated, unsweetened	.5		

Its fuel value is about 2,735 calories.

Enlisted men supplied with travel rations may, in lieu of the coffee, milk and sugar components thereof, receive funds for the purchase of liquid coffee, at the rate of 21 cents per day for each man.

V. Filipino Ration.

Issued to the Philippine scouts (Philippine Islands).

Component articles and quantities		Substitutive articles and quantities in ounces	
Beef, fresh	12 oz.	Bacon	8
		Canned meat	8
		Fish, canned	12
		Fish, fresh	12
Flour	8 oz.	Hard bread	8
Baking powder, when in field and ovens are not available	.32 oz.		
Rice	20 oz.		
Potatoes	8 oz.	Onions	8
Coffee, roasted and ground	1 oz.		
Sugar	2 oz.		
Vinegar	.08 gill		
Salt	.64 oz.		
Pepper, black	.92 oz.		

The components of the ration yield a maximum fuel value of 3,980 calories.

VI. Emergency Ration.

Issued to troops in active campaign for use on occasions of emergency, when no other food is procurable. The can in which it is contained is not to be opened except by order of an officer or in extremity.

It consists of three components: 1, wheat and meat; 2, chocolate; 3, seasoning.

The wheat (No. 1 hard wheat) is boiled, then kiln-dried and after removal of the outer hull of bran, parched and ground to a coarse powder. The meat is prepared from fresh lean beef thoroughly desiccated (under 160° F.) and ground to a fine powder. The wheat and meat are combined in the proportion of 2 to 1 (with a little salt), thoroughly mixed into a homogeneous product, then compressed into cakes weighing 3 ounces each.

The chocolate, made of the best material, is molded into cakes weighing 1 ounce each.

The seasoning consists of salt and black pepper.

Each complete ration consists of 3 wheat and meal cakes, 3 chocolate cakes, salt and pepper; it weighs 12 ounces net, packed in a hermetically sealed, key-opening, khaki-colored lacquered can.

The wheat and meat component may be eaten dry, or stirred into cold water; or it may be boiled into a soup or porridge. The chocolate may be eaten dry, or made into liquid by placing it in a tin cup held in hot water; after melting, boiling water is slowly poured in, one pint to a cake.

According to Langworthy, it consists of 102 grams of proteid, 54 of fat and 153 of carbohydrates, with fuel value of 1,500 calories. It is obviously faulty in having too much proteid and not enough carbohydrate, for it is muscular energy that it is particularly called upon to supply.

A serious objection against this ration is that it requires special plants for its preparation, so that in case of mobilization on a large scale, the supply would utterly fail. The War Department has determined to simplify the components in order that it may be readily prepared, in case of need, by a sufficient number of manufacturers. The experiments already conducted to that end indicate that, in the new emergency ration, the fat (about 31 per cent.) will be furnished chiefly by cocoa butter and chocolate, the carbohydrates (about 35 per cent.) by malted milk and sugar, the protein (about 25 per cent.) by beef, nucleo-casein or desiccated egg, and the stimulating principle by theobromine. It will weigh half a pound and yield about 1,325 calories. This ration will also be seriously deficient in carbohydrates.

THE RATION OF THE UNITED STATES NAVY.

This ration consists of the components embraced under 1, 2 and 3, and of a weekly allowance of other articles as enumerated below.

	Component articles and quantities		Substitutes when deemed necessary by the senior officer present	
1	Salt or smoked meat	20 oz.	Fresh meat or fresh fish or 8 eggs.	28 oz.
	Fruit, dried or canned or preserved Flour or beans or peas	6 oz. 6 oz. 12 oz. 3 gills	Fresh vegetables	28 oz.
2	Preserved meat	16 oz.	Fresh meat or fresh fish or 8 eggs.	28 oz.
	Fruit, dried or canned or preserved Rice or canned vegetables or desiccated vegetables	3 oz. 6 oz. 8 oz. 12 oz. 6 oz.	Fresh vegetables	28 oz.
3	Biscuit	16 oz.	Soft bread or flour	20 oz. 18 oz.
	Butter	2 oz.		
	Sugar	4 oz.		
	Coffee or cocoa	2 oz.		
	or tea	½ oz.		
	with condensed milk or evaporated cream	1 oz.		
	WEEKLY:			
	Macaroni	4 oz.		
	Cheese	4 oz.		
	Tomatoes	4 oz.		
	Vinegar or sauce	½ pint		
	Pickles	¼ pint		
	Molasses	¼ pint		
	Salt	4 oz.		
	Pepper	½ oz.		
	Spices	⅛ oz.		
	Dry mustard	½ oz.		
	Lard or suitable substitute	7 lbs.	for every 100 lbs. of flour issued as bread.	
	Yeast and flavoring extracts as necessary.			

The following substitutes can likewise be issued when authorized by the senior officer present.

For		Substitute	
Beans or peas	3 gills	Flour or rice or other starched food or canned vegetables	12 oz. 8 oz. 8 oz. 12 oz.
Condensed milk or evaporated cream	1 lb.	Fresh milk	1 quart

For		Substitute	
Dried fruit	3 oz.	Fresh fruit	9 oz.
Canned or preserved fruit	6 oz.	Fresh fruit	9 oz.
Flour	12 oz.	Beans or peas	3 gills
Rice or other starched food	8 oz.	Beans or peas	3 gills
Canned vegetables	12 oz.	Beans or peas	3 gills
Macaroni	4 oz.	Sugar	3 lbs.
Cheese	4 oz.	or condensed milk	1½ lbs.
Vinegar or sauce	½ pint	or coffee	1 lb.
Pickles	½ pint	or canned fruit	1½ lbs.
Molasses	½ pint	or canned vegetables	4 lbs.
Spices	⅛ oz.	or flour	4 lbs.

An extra allowance of one ounce of coffee or cocoa, two ounces of sugar, four ounces of hard bread or its equivalent, and four ounces of preserved meat or its equivalent are allowed to enlisted men of the engineer and dynamo force who stand night watches between 8 o'clock postmeridian and 8 o'clock antemeridian, under steam.

This ration provides a great variety of foodstuffs and condiments and permits almost any substitutes so as to give it perfect adaptability to all climatic conditions. It is only open to the criticism that, in quantity, it is manifestly in excess of requirements, and that its issue may be attended with serious risks of overfeeding and waste.

THE RATION IN FOREIGN ARMIES.

France.—In France, four types of rations are provided, two for peace (garrison ration and maneuver ration) and two for war (ordinary and large field rations).

Their components are as follows:

Articles	Garrison ration	Ordinary field ration	Large field ration.
	Kg. Grams	Kg. Grams	Kg. Grams
Soft bread (brown)	0.750	0.750	0.750
Soup bread (whi e)	0.250	.....	.....
Fresh beef	0.320	0.400	0.500
Rice	0.030	0.060	0.100
or pulses	0.060	0.060	0.100
Lard	0.030	0.030	0.030
or beef suet	0.040	0.040	0.040
Salt	0.016	0.020	0.020
Sugar	0.021	0.021	0.031
Coffee	0.016	0.016	0.024

The soft bread ("pain de munition") is a leaven-made bread from flour bolted to 20 per cent.; it may be replaced by hard bread and partly by

Italian pastes and flours of cereals; the beef, by any kind of fresh or preserved meat, fish, cheese or milk; the rice and pulses, by any available dry or green vegetables.

In bivouac, or whenever ordered by the commanding general in the field, a liquid ration is issued of either wine (1/2 pint), beer (1 pint) or brandy (2 oz.).

The garrison ration contains (according to Rouget and Dopter):

Proteids,	125.06 grams, yielding	513 calories.
Fats,	60.46 grams, yielding	562 calories.
Carbohydrates,	573.52 grams, yielding	2351 calories.
Total,		3426 calories.

The maneuver ration contains less proteid and fat having a fuel value of 3,164 calories.

The ordinary field ration contains:

Proteids,	123.60 grams, yielding	507 calories.
Fats,	64.74 grams, yielding	602 calories.
Carbohydrates,	476.99 grams, yielding	1956 calories.
Total,		3065 calories.

Soup bread may be added if available (which is seldom the case), increasing the total calories to 3,687.

The fuel value of the large field ration (without soup bread) is 3,383 calories.

The French soldier takes two meals a day, breakfast at 10 A. M. and dinner at 5 P. M., besides black coffee at reveille.

In time of peace, the commissary department supplies only hard bread, sugar and coffee, as well as wine and brandy when authorized. The rest of the ration is purchased by the company messes ("ordinaires") from special money allowances (about 10 cents per man), under the supervision of a council appointed by the commanding officer ("commission des ordinaires"). Money allowances remaining unexpended, that is, resulting from savings on the ration, as well as proceeds from fines, sale of wastes, etc., are used in purchasing such additional articles of food as deemed desirable.

In war, the men carry two days rations in the haversack; two more are carried in the regimental trains and four on the administrative trains.

Germany.—In Germany, four types of rations are also provided, two for peace time and two for the field. The large peace ration, such as issued during maneuvers, contains, according to Roth, an average of 155

grams of proteid, 39 of fat and 538 of carbohydrates, with fuel value of 3,202 calories. The other peace ration is much smaller and, in certain garrisons, has to be supplemented from the private means of the soldier. The small field ration averages 141 grams of proteid, 51 of fat and 458 of carbohydrates, with fuel value of 2,929 calories; the large field ration, 181 grams of proteid, 64 of fat and 558 of carbohydrates, with fuel value of 3,625 calories.

The commissary furnishes bread and meat, most of the other articles being purchased out of a daily allowance of 4 cents per man.

The German soldier takes a cup of black coffee, or coffee with milk, and bread in the morning, dinner at noon and a light supper in the evening. During maneuvers, or in the field, he may also receive 1 quart of beer, 1 pint of wine or about 3 ounces of spirits.

Great Britain.—The ration of the British soldier, in garrison, consists of 16 ounces of bread, 12 ounces of meat, and such additional articles (vegetables, groceries) as are purchased out of a daily allowance of 7 cents. During maneuvers the meat is increased to 16 ounces.

In the field, his ration varies according to climate and the character of his work; it generally consists of 16 ounces of salted or preserved meat, or 16 to 20 ounces of fresh meat; 20 ounces of fresh bread or 16 ounces of hard bread or flour; 1 ounce of compressed vegetables, or 8 ounces of potatoes (or other fresh vegetables), or 2 ounces of rice (or split peas), or 4 ounces of onions; coffee, tea or chocolate, sugar and the usual condiments. Two ounces of spirits and some tobacco may also be allowed.

An emergency ration is provided in the British Army, for use only when no other food is procurable and when authorized by the commanding officer. It is contained in a flat can and consists of chocolate, sugar and proteid in the form of "plasmon," weighing 6 1/2 ounces net. According to Langworthy, its proximate principles average: proteid 59 grams, fat 50 and carbohydrates 65, with fuel value of 973 calories. This ration, like our own emergency ration, is too rich in proteid and deficient in carbohydrates.

Russia.—The Russian soldier, in the field, receives 2 1/4 pounds of black bread (from unbolted rye flour), 14 1/2 ounces of fresh meat or 11 of preserved or salt meat, 9 ounces of green vegetables or the equivalent in compressed vegetables, 1 to 2 ounces of suet or butter for cooking, together with 4 to 5 ounces of grits, tea, sugar and condiments.

Most of the articles of the ration (bread excepted) are boiled together in a large wheeled kettle and served as soup (see p. 200).

Japan.—The Japanese ration, in the field, consists of:

Rice, uncooked, 30 ounces.
or steamed and dried, 25 ounces.
or fresh bread, 20 ounces.
or hard bread, 13 ounces.
Meat, canned, 10 ounces.
or fresh (with bones) 13 ounces (which may be increased to 20 if procurable).
or salt, dry or smoked meat, 8 ounces.
or fish.
Vegetables, dry, 8 ounces.
or green, 32 ounces.
Pickles, sauces and condiments.
Tea and sugar.
Sake (beer made from rice).

The Japanese soldier does not take readily to bread, either fresh or hard. During the Russo-Japanese war, the meat component was scant and issued irregularly; rice, fish and vegetables formed the staple ration.

The Japanese medical regulations provide that the nutritive value of the ration should never fall below 2,580 calories.

Emergency Ration.—All foreign armies have a so-called emergency ration, but, with the exception of England, it is nothing else but a field ration in a more condensed and portable form, consisting of hard bread, and preserved meat and vegetables in cans.

CHAPTER XIX.

CONCLUSIONS.

In a previous chapter it was stated, on good grounds, that an adult man weighing 154 pounds is in better physical condition, stronger and capable of greater endurance, with a ration yielding 2,800 calories, especially if the proteids are kept within a maximum of 60 grams, than with one greatly exceeding this value. But we have seen that in our service, as in all other leading countries, the soldier's ration exceeds these limits in the number of calories which range from 3,000 to 5,000, but especially in the amount of proteids (Japanese excepted) which hardly ever falls below 100 and often ranges up to 160 or more grams. There is no indication therefore that, in this country or in Europe, the soldier is underfed, provided he actually receives the ration called for by military regulations.

Much has been written on the necessity of feeding the soldier well, and much attention and study have been devoted to the composition of adequate rations. That he should be sufficiently and properly fed needs no discussion, but the belief generally entertained that the more he eats the greater is his energy and efficiency is groundless and mischievous. The danger of overeating has been too much overlooked, or else esteemed a negligible factor. It is the opinion of many careful observers that the American soldier is much more likely to be overfed than underfed, and that his health and efficiency stand in greater peril from excess than from lack of food. As a general rule, the soldier does not know how to regulate his appetite, nor does he appreciate the necessity of doing so. He eats what is allowed him hurriedly and often without proper mastication, and, between meals, frequently patronizes the lunch counter of the post exchange or the outside shop where pies and other tempting pastry are displayed. This is characteristic of the soldiers of all countries, particularly of those who receive the most liberal rations. Thus the remarks of Rouget and Dopter, in their "Hygiène militaire," although aimed at their countrymen, are of very general application. "Many Frenchmen, especially in the country, have the pernicious habit not to cease eating until they experience a sensation of fullness in the stomach. Little do they care about the nutritive value of the food ingested. Their conviction is that, so long as this abdominal repletion is not distinctly felt, they have not

been sufficiently fed. This is particularly observed each year at the time of the incorporation of the new contingent. The amount of bread in the ration, although considerable, is not enough to satiate these young soldiers; they buy more from outside bakeries."

It should be remembered that within an hour or two after taking a full meal, at least a pint of gastric juice is poured into the stomach and added to its contents, so that what was at first mere repletion may become uncomfortable distention. Soldiers should be advised that a sensation of fullness or distention following a meal is a clear admonition that they have eaten too much, and that if such excess is kept up, as a habit, they will surely suffer in health and efficiency. Such advice may do good, but more practical results will follow if the food, especially the meat, as served in the mess-room, is simply sufficient and not wastefully abundant.

Experience shows that it is while actively engaged in the field, when the rations are reduced and the cooking simple, that the men enjoy the best health and show most endurance, provided, of course, there is no actual lack of food. Thus, during the active part of the Santiago campaign, in 1898, there was but little sickness in spite of the trying climate and of short commissary supplies, but as soon as the work was over and rations became abundant, the morbidity began to rise and before long exceeded 75 per cent. of the command. It is hard to resist the conviction that injudicious feeding was responsible for many of the cases of "undetermined fever" and prepared the way for much of the malaria which prevailed in our camps near Santiago, as well as of the typhoid fever which decimated our troops in the United States. It is noteworthy that the Spanish soldiers in Santiago, although reduced to very scant rations of poor quality, had a much smaller proportion of sick than the American troops. During the Boer War, in South Africa, the English troops besieged in Ladysmith were fed for several months, according to Dunlop, on a ration of 73 grams of proteid, 69 of fat and 141 of carbohydrates, with fuel value of only 1,527 calories, yet, as remarked by Munson, it furnished energy enough for a stout and successful resistance. The Russo-Japanese War has taught us an important lesson in dietetics. Both Russians and Japanese had meat rations much smaller than those provided for American, English and French soldiers; the meat ration of the Japanese, in particular, was decidedly meagre and often lacking altogether. Yet we know that no armies, during an arduous war of twenty months, ever suffered so little from infectious diseases and had fewer men incapacitated from sickness. To what extent this immunity is due to the food can only be conjectured. It certainly cannot be attributed exclusively to the

sanitary measures taken, for it was the opinion of the American and English attachés with both armies, that had their own troops been placed under similar conditions, but fed with their own rations, typhoid fever would undoubtedly have prevailed among them in an epidemic form. It is true that the Japanese suffered much from beri-beri during this war, but it is a well-known fact that they had more and better food in the camps around Port Arthur, for instance, where this disease was prevalent, than they had been accustomed to in their homes where beri-beri is comparatively uncommon, so that scant proteid diet cannot be held responsible for it.

In determining the composition of the soldier's food, two different aspects of the question should be considered: the ration proper, as prescribed in regulations, and the amount of nutriment actually needed to keep him in the best physical condition. In our Army, the articles of the ration may be consumed as such or else converted into cash which is turned into the company or mess fund. This fund is expended by the company commander for the purchase of articles of food not issued by the Subsistence Department and for other articles, not for consumption, intended for the needs, comfort and enjoyment of the men, such as furniture, games, periodicals, etc. Therefore, so long as the ration, as allowed by the government, is not exclusively used for the feeding of the men but is susceptible, in part, of conversion into cash for the procurement of anything deemed to be for their benefit, it is evident that, from a physiological point of view, there is no limit to the quantity of the components of such ration; it becomes an economic rather than a hygienic question. The only aspect of the subject which concerns the hygienist is what part of the ration should be actually consumed, and in what form.

As the outcome of the latest study and experience in the physiology of nutrition among adult men, we may state that, in garrison or camp, the fuel value of the ration actually consumed need not be over 2,800 and should never exceed 3,000 calories, and that there must be very few circumstances in the field, except in a very cold climate, when a value of 3,500 calories is desirable or necessary. Half a pound of beef, when freed from bones and other waste, is reduced to about 6 ounces which, with the proteids of other foodstuffs of the ration, exceeds the 60 grams we have seen to be quite sufficient for the daily needs of the active body. It is therefore unphysiological, wasteful and against the best interest of the soldier and of the service to give him, while in garrison or camp, much more than that amount of beef or its equivalent of other meats, nor is it ever necessary in the field to exceed one pound. The solicitude of all

officers concerned should not be how to increase a ration already extremely liberal, but to make it comprise as many components as possible, to see that these components are most advantageously combined to secure variety, that they are cooked, seasoned and served in the most digestible and appetizing manner, and that the men be made to understand the advantages of thorough mastication. In the field, or wherever a desirable variety of food cannot be obtained from the commissary, every effort should be made to convert part of those components allowed in excess, especially meats and fats, into lighter and healthier articles, according to what local markets afford.

CHAPTER XX.

THE RATION OF THE UNITED STATES SOLDIER IN THE TROPICS.

The climatic conditions characteristic of the tropics are a constant high temperature and great relative humidity. The effects of these conditions upon the body, so far as food is concerned, may be stated thus:

1. Increased bodily temperature (half degree or more) and diminished loss of heat from radiation, convection and respiration.

2. Loss of flesh, especially of fat, so that the normal weight is reduced several pounds.

3. Decreased oxygenation, from the expansion and rarefaction of the air and lower atmospheric pressure.

4. Greatly increased perspiration, causing a diminution of urine and of the digestive fluids.

5. General depression of the nervous system and loss of vital energy, with weakening of the digestive and assimilative functions, as well as diminished power of mental application and muscular action.

The normal physiological amount of food required for the needs of the body is smaller in the tropics than in temperate regions. Man, there, is not capable to absorb and assimilate the same quantity, nor has he the same craving for it. The loss of heat from the body being smaller, less fuel is needed to maintain the temperature required for the performance of all its functions. The decreased oxygenation is an important factor in considering the question of alimentation in the tropics; the constructive and destructive metabolism of tissues depends chiefly on the amount of available oxygen present, and food is useless or detrimental which for want of it cannot be converted into assimilable bodies or else broken up and eliminated. The loss of weight, the weakened power of digestion and assimilation, the diminished physical vigor and muscular exertion, are so many reasons for a corresponding reduction in the diet. Increased perspiration diminishes the amount of urine and output of urea, so that more work is thrown upon the liver and skin as excretory organs. Unless the food is suitably adjusted to the new conditions, there is danger of hepatic congestion, with subsequent inflammation and degeneration, as frequently seen in hot climates. (See *Service in Warm Climates*.)

These theoretical considerations are confirmed by the established dietary habits of people living at different latitudes; in other words, we find that the nutritive amount of food consumed by the same class of laborers diminishes as we advance from the northern portion of the temperate zone to the tropics. Thus the Department of Agriculture (Bull. 38 and 71) has shown that while negro families in northern Virginia consume 109 grains of protein, 159 of fats and 444 of carbohydrates, with fuel value at 3,745 calories, families of the same class in southern Alabama only consume 62 grams of protein, 132 of fats and 436 of carbohydrates, with fuel value of 3,012 calories. The fuel value of the food consumed by the natives of all tropical countries is estimated to range from 2,000 to 3,000 calories.

Admitting that a reduction of the soldier's ration, as adjusted for temperate climates, is necessary in the tropics, the next question is in which of the proximate principles should it be made; undoubtedly in the fats and proteids.

Fats are only digestible to a limited extent, according to the needs of the body. When taken in excess they are extremely apt to split up in the stomach into irritating acids which, together with hepatic congestion and disturbed bile secretion, produce the condition known as biliousness, often attended with putrefaction of the intestinal contents and catarrhal inflammation of the bowels. As fats contain but little oxygen, they are often unable to obtain the large amount of it required for their complete combustion, thus becoming an incubus in the system; on the other hand, if completely metabolized they evolve much more heat than is desirable. It is not contended that all fats should be banished from the tropical ration; a certain amount is necessary, but this should be very moderate and in the most acceptable form. Vegetable oils have been recommended. The butter accompaniment of the daily bread, if not entirely left out, should be reduced to a minimum. Bacon, when well cooked so as to be dry and granular, is quite acceptable even in hot countries.

The reasons before urged for a reduction of proteids in temperate zones apply with still greater force in the tropics where the digestive functions, oxygenation, metabolism and elimination are more or less impaired. The amount of proteids which is digested and utilized in a temperate zone may here overload the system with unoxidized nitrogenous waste, or else, if oxidized and discharged by the kidneys as urea, strain these organs already functionally weakened by a diminished excretion of urine. Proteids, although reduced in quantity, should be as varied and

digestible as possible. Beef can be now and then replaced by mutton, often by fresh fish which is always good and abundant in the tropics, while eggs, cheese, beans (frijoles) and macaroni will also help in furnishing the necessary nitrogen in acceptable forms. Fish is often objected to by the company cook and left out of the men's dietary simply because of the trouble in preparing it, a striking instance of the indifference of some company commanders in the discharge of one of their most important duties.

All authors agree that, in the tropics, carbohydrates should form the best part of the dietary. They are the most easily oxidized of the proximate principles, the most readily metabolized and eliminated, their decomposition products being simply aqueous vapor and carbon dioxid.

The natives of tropical regions obtain their food almost entirely from the vegetable kingdom, consisting chiefly of bread, rice, beans, vegetables, fruit, coffee and sugar, to which poultry, eggs and fish are occasionally added; hence the natural inference that this diet is likewise the best adapted to the needs of white people in the tropics. Such an inference, correct in the main, needs to be qualified; the natives did not consciously select their diet; as a rule, they are ignorant, indolent and poor, and therefore consume the food procured with the least effort and expense. There is no doubt, however, that this food, which is mostly that provided by nature, is the best for them; its chief defect is a lack of variety. As soon as they can afford it they are but too apt to buy the viands and more appetizing foods of the higher classes, thereby losing their native immunity to various infectious diseases and becoming liable to the ills of those whites who neglect to adjust their habits to climatic conditions.

Munson, in his masterly study of the subject,* proposes several dietaries for the soldier in the tropics, in which the proteids vary from 123 grams to 104, the fats from 114 grams to 10 and the carbohydrates from 630 grams to 517, with fuel value ranging from 2,947 to 3,825 calories. As already seen from the conclusions drawn above, such liberal allowances cannot be accepted as representing the actual amount of food needed by the body in the tropics, but, to some extent, may be used as the basis of the ration to be actually issued.

It does not seem desirable to make the tropical ration different from the general regulation ration; it may be assumed that the excess in many of the articles can be converted into cash with which other food articles, better adapted to the climatic conditions, can be purchased either from the commissary or from local markets. Care, however,

*The ideal ration for an army in the tropics, 1900.

should be taken that such liberal policy does not engender wasteful habits. The important point to determine is the amount of proximate principles which, in the performance of the ordinary duties of garrison and camp, is actually needed by the men, to be used as a guide by the officers in command of organizations, so as to provide plenty and at the same time avoid overfeeding. It has been seen that this amount, in temperate zones, does not exceed 60 grams of proteids and about the same quantity of fat, with enough carbohydrates to yield a fuel value of 2,800 calories. This then should be the maximum for the tropics, to be exceeded only in case of unusually arduous work. It is furnished by the following quantities of the ordinary components of the ration.

Articles	Quantity.
Fresh beef,	10 ounces
or fresh mutton,	10 ounces
or pork,	6 ounces
or bacon,	6 ounces
or dried fish,	10 ounces
or fresh fish,	16 ounces
Flour,	15 ounces
or soft bread,	15 ounces
or hard bread,	12 ounces
Beans,	2.4 ounces
or peas,	2.4 ounces
or frijoles,	2.4 ounces
or macaroni,	2.4 ounces
or rice,	4 ounces
Potatoes,	16 ounces
or substitutes,	16 ounces
Dried fruit,	
Sugar,	
Coffee,	
or tea.	

Such ration will yield at least 3,000 calories and, after making allowances for wastes, comes up fully to requirements.

The best cereal and one of the best foods for tropical regions is rice; therefore an effort should be made to cook and season it in an appetizing manner, not boiling it into a gelatinous, sticky mass, but so that each grain, when thoroughly cooked, stands unbroken, separate and dry.

As pointed out by Kean, it is a blunder to make potatoes an indispen-

sable article of the tropical ration and export them, at great trouble and expense, to our colonial possessions where native roots, tubers and fruits, at least equally palatable and nutritious, can be readily obtained. Potatoes rapidly decay in transit or when stored in hot countries, and most of them become unfit for use before they can be issued to the companies. In the tropics it is generally possible to procure sweet potatoes, various kinds of cucurbits (squash family) and of yam, cassava (manioca), taro (*colocasia*), tannier (*caladium*), etc., and any number of palatable fruits. It should also be made one of the important duties of the cook to learn how to prepare them for the table. Tropical fruits, contrary to popular prejudices, if mature and not over ripe, are all perfectly wholesome.

In attempting to change the quantity and quality of the ration in the tropics, it is well to bear in mind the strong influence of habit. The soldier going from the United States to our colonial possessions quickly understands the necessity of a change in his clothing, but is slow in realizing that of a change in his diet, and any attempt to reduce too rapidly the quantity of food he has been accustomed to will be strongly resented. In this, as in other things, he should be properly instructed; the advantages of such a reduction must be pointed out to him so that he may submit to it intelligently and more completely appreciate the benefits of it.

CHAPTER XXI.

RULES TO BE OBSERVED IN EATING AND DRINKING.

The general hygienic rules to be observed in eating and drinking, in order to maintain our best health, may be summed up as follows:

1. Let the food be simple but nutritious and varied, containing all the proximate principles in suitable proportion; the digestive organs soon tire from the same articles while they are stimulated by change and new combinations. Highly seasoned food, rich pastry and savory cheese should be the exception, never the rule. Pungent condiments are pernicious; for a while they excite the digestive glands to abnormal action but eventually cause diminished secretion and dyspepsia.

2. Cook it properly so as to bring out its savors, promote a free flow of digestive fluids and cause its prompt disintegration therein.

3. Eat slowly and masticate thoroughly, for unless the food is properly cut and ground by the teeth, lumps of it will escape the action of the saliva and gastric juice, not only remaining undigested but likely to ferment and give trouble.

4. Do not drink more water at meals than necessary to soften and mix the food; to quench the thirst, drink between meals.

5. Avoid dishes or beverages too hot or too cold, for extremes of temperature check the secretion of the gastric juice, while their alternations may fissure the enamel of the teeth.

6. Do not divert blood from the stomach during active digestion by mental or physical work. Rest of body and mind, or at least abstention from active exercise, is necessary for a few moments before meals and for about an hour afterward. Depressing thoughts and business preoccupations should be banished from the table.

7. Observe regularity in the hours for meals, so that the digestive juices may be poured out more abundantly at the accustomed times.

8. Avoid over-indulgence or intemperance in eating, for not only does the stomach resent abuse, but the whole system becomes clogged and the congested and strained organs function imperfectly.

CHAPTER XXII.

BEVERAGES.

Beverages are conveniently divided into alcoholic and non-alcoholic. Of the non-alcoholic beverages, those which especially concern the soldier are coffee, tea and chocolate.

Coffee is the name of the seed of the shrub *Coffea arabica* cultivated in many tropical countries, as well as of the beverage prepared from it. Except in the hands of an expert, it is difficult to judge of the quality of the seed, or berry, from its size, shape or color as these vary considerably on the same plant and are otherwise easily altered. By roasting the green berries until they acquire an even, dark reddish-brown color, characteristic aromatic and empyreumatic principles are developed; as they are volatile, coffee should be roasted only a short time before being used; for the same reason, roasted coffee should be kept in tight vessels and only ground as needed. The taste is often much improved by the addition of a little butter and sugar before roasting. The composition of roasted coffee is about 2 per cent. of water, 1 of caffeine, 12 of fatty matters, 12 of nitrogenous substances, 4 or 5 of tannic acid, very little sugar, a large amount of cellulose and extractive matters and nearly 5 of mineral salts. The principal active constituent is the alkaloid caffeine, of which a cup of black coffee contains about 1 1/2 grains.

The berry should be ground into a coarse powder; if ground too fine, part of the flavor is destroyed. In order to preserve its aromatic principles coffee should be prepared only by infusion. The ground coffee is put in boiling water, two or three heaping tablespoonfuls to the quart, and then the pot removed far enough from the fire to keep it just below the boiling point for 10 to 15 minutes.

Coffee is a useful nervous and gastric stimulant, and if used in moderation does not produce depressing after-effect or any untoward result; it has also slight cathartic and diuretic properties. When taken very freely it is liable to cause general nervousness, insomnia, functional disturbance of the heart and derangements of all the digestive functions. It is not so well borne by dyspeptics as tea.

Tea consists of the leaves of the shrub *Thea chinensis* cultivated in many tropical and semi-tropical countries. Tea of excellent quality is

grown in our Southern States. Green tea and black tea differ only in the method of preparation; the former being immediately dried after picking, and the latter previously allowed to undergo a slight degree of fermentation. Black tea is generally higher in caffeine and much lower in tannin than green tea. According to König, average tea contains 21.22 of nitrogenous matters, 1.35 of theine, 0.67 of volatile oil, 10.75 of fat, resin, gum, etc., 7.76 of tannic acid, 37 of other extractives, cellulose, etc., and 5.11 of mineral matters. Its active principle, theine, is identical with caffeine, and quite variable in quantity, sometimes amounting to 3 per cent. in black teas.

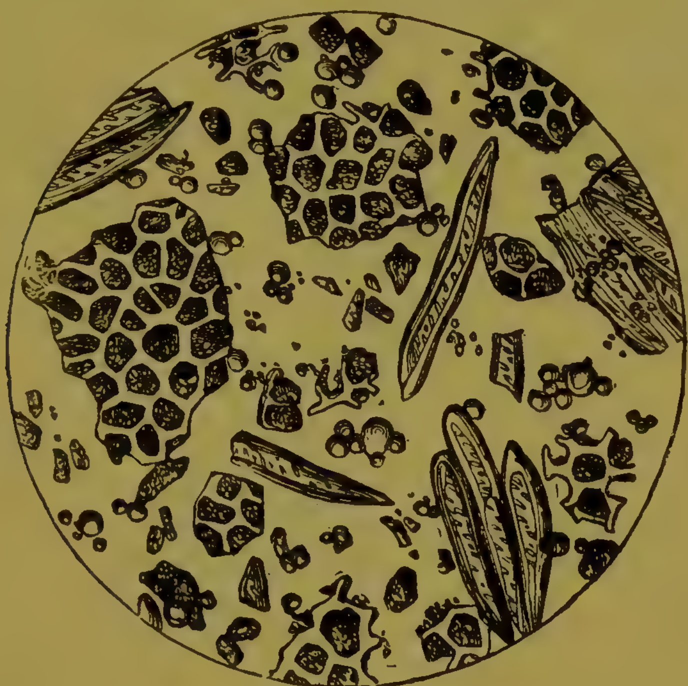

FIG. 70.—Coffee roasted and ground, free from all adulteration. (*Hassall.*)

Tea, as beverage, should be made, like coffee, by infusion. Boiling dissipates the aroma and dissolves much of the astringent and bitter principles. As the quality of tea depends largely upon the mode of its preparation, the following rules should be observed: Take fresh water, not water that has become flat by standing on the stove or in the waterback; bring it quickly to a hard boil; fill the teapot and set it on the fire for one minute in order that it may get thoroughly heated; pour off the water and put into the pot one teaspoonful of the leaves for every teacupful of tea that is to be drawn, and one for the pot; then pour on the boiling water and set the covered pot on the stove or near the fire to "draw" but not to boil. It

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should draw just enough to liberate the essential oil which constitutes its aroma, but not long enough to drive it off or to dissolve the tannin which gives the tea a disagreeable taste. The time varies with the different teas, from five to ten minutes. (Manual for Army cooks.) The most delicate portion of the infusion is that poured off within three or four minutes.

It has been seen that the leaves of tea are richer in caffeine than the berries of coffee; for this and other reasons, less of the former is needed to make the same quantity of infusion. According to Geo. F. Mitchell (Dept. of Agric.), to prepare a cup of tea 30 grains of the leaves are used, and to prepare a cup of coffee 75 grains of the ground berries. The cup of tea contains approximately 0.84 grain of caffeine, and that of coffee 0.83 grain.

Should the soldier use coffee or tea in the field? Both are gentle stimulants which cheer and refresh, relieving fatigue and the sensation of hunger. The addition of sugar and cream gives them decided nutritive value and increases their power to evolve muscular energy. Coffee, among male adults, is more generally used than tea in this country, as well as in France and Germany, while tea is preferred in England, Russia, Japan and China. This appears to be in a large measure a matter of habit and custom. There is good evidence that, to relieve thirst on a hot or cold day, as well as to appease hunger and sustain energy, nothing is quite so satisfying as a glass of tea; the extended experience of English officers on the torrid plains of India, as well as that of Russians in Siberia and Manchuria, appears to be conclusive on that point. It seems also that more caffeine can be taken with impunity in the form of tea than as coffee.

For the soldier in the field tea possesses some obvious advantages. It is much easier to transport, preserve and prepare. The weight and bulk of enough tea, in compressed tablets, to last a soldier a week is a negligible quantity in his haversack. Not only is coffee heavier and more bulky, but its proper roasting and grinding in the field is often a difficult process, or, if issued roasted and ground, great care is required to prevent deterioration. The most practical way to use coffee in the field is in the form of compressed cakes with impervious wrappers, as in the French service, or of a strong and stable liquid extract requiring nothing but the addition of hot water, such as is being experimented with in the Russian service. Tea and coffee being prepared with water that has been boiled are sterilized beverages and of great value wherever water is contaminated; but tea being more aromatic than coffee can be diluted to a much greater extent without ceasing to be palatable, therefore can be used practically

ad libitum and more readily take the place of water as a safe drink. In the absence of fire, good tea can also be prepared with cold water if time permits. The tannin in tea is objectionable on account of its astringent and constipating effect, but a properly prepared infusion, especially when diluted, never contains enough of it to be harmful. On the other hand, tannin in tea is not without redeeming features; it may render good service in diarrhea and, as an antiseptic, may help to purify water that can not be boiled.

Cocoa is derived from the seeds of *Theobroma cacao*, a tree of tropical America, in no way related to the cocoanut palm. The fruit is a ridged, pointed pod, six to ten inches long, containing from 25 to 40 seeds or "beans." These undergo a process of fermentation, then are dried in the sun, roasted and freed from the germs. Mixed with about an equal quantity of sugar and spiced with vanilla beans and cinnamon, they constitute the ordinary sweet chocolate. Cocoa contains 13 per cent. of proteids, 49 of fat (cocoa butter), 13 of starch and 2 or 3 of potassium phosphate. It contains also an average of 1.50 per cent. of the alkaloid theobromine, closely related to caffeine but somewhat less stimulant. The principal constituents of good chocolate are 57 per cent. of sugar, 22 of cocoa butter, 1.33 of theobromine, 4.75 of proteids and 1.48 of tartaric acid.

Cocoa, therefore, especially as chocolate, is not only a mild stimulant but, unlike tea and coffee, a valuable food in condensed form, capable of evolving much muscular energy in time of need. Chocolate is an important component of the emergency ration and an excellent article for the soldier to carry in his haversack whenever rations are scant and the work arduous.

ALCOHOLIC BEVERAGES.

These beverages include: 1, fermented drinks, either made from malt, such as beer, ale and porter, or from saccharine liquids and fruit juices, such as wine and cider; 2, distilled drinks, the product of distillation of fermented saccharine solutions, such as whiskey and brandy.

The active and essential principle of all these beverages is ethylic alcohol in variable quantity.

The food value of alcohol and its effects upon the economy is a subject beset with difficulties, one studied by many physiologists but often with contradictory results. The following conclusions are those now generally accepted. Atwater has demonstrated that if alcohol, in small quantity and for a few days, is made to take the place of its isodynamic equivalent

of fat in the diet, the number of calories evolved remains the same; therefore, that within certain limits, alcohol is oxidized and a real food. It is more than doubtful, however, whether the result would be equally satisfactory with higher doses continued for a longer period. Daily experience indicates the contrary, for if it is true that alcohol can to some extent be oxidized in the system, its toxic properties are none the less real. Cheveau has shown that when alcohol is substituted for some time to the fats, the muscular energy falls and the body weight decreases. The sensation of warmth experienced after the ingestion of an alcoholic drink is due to the dilatation of the peripheral and pulmonary capillaries; but this is soon followed by a more active radiation of heat and increased evaporation, so that the loss exceeds the grain; thus after an ordinary intoxication the body temperature may fall 2° or 3° F. below normal. It is generally admitted that, except in small doses, or when the body actually lacks food, the temporary increase of pulse, respiration and muscular energy produced by alcohol is succeeded by a stage of depression which more than offsets the good effects of the stage of stimulation.

As a medicine, alcohol, under many forms, has doubtless a useful part to play, and is often advantageously administered in cases of exhaustion or heart failure, but even in such cases other stimulants may be preferable. It should always be given in small quantities and its effects watched, for the toxic dose is soon reached and the second state of the patient may be worse than the first.

In health, physiologists agree that alcoholic beverages are unnecessary, and the statistics of insurance companies tend to show that total abstainers may expect a greater longevity than even those who indulge in moderation. The use of whiskey, wine or beer, formerly pretty general in armies and navies, as part of the ration, is now restricted to exceptional occasions of fatigue and exposure and, in some countries, as in ours, completely suppressed. There are doubtless circumstances in very cold and very hot regions when a little wine or small amount of diluted whiskey may be beneficial, but the difficulty of correct dosage and the danger of over-indulgence are so great that it is safer, if we wish to obtain the best results from our nervous and muscular energy, to trust to coffee, tea and chocolate.

Concerning the use of alcoholic beverages, several points must be borne in mind. The most important is that the active toxic principle is alcohol and not any of the impurities which may be associated with it; the proportion of these, as a very general rule, is much too small to produce any appreciable effect. The various manifestations of alcoholism, there-

fore, are due to the *quantity*, not to the *quality* of the alcohol. The exception to this rule is in the case of absinthe, vermouth and various bitters in which poisonous essential oils are used. Another point is that the more diluted the beverage, the less likely is the passage into the blood of enough alcohol at any time to produce toxic symptoms, and the less harmful the result. Thus France is said to consume more alcohol than any other nation (Arnould), but as much of it is in the form of wine, alcoholism does not appear to be worse there than in several other countries. Spain and Italy consume large quantities of alcohol, but also mostly as wine, and they are among the countries which suffer least from alcoholism. All observations tend to show that, for those who desire or need an alcoholic beverage, the most acceptable, that provided by nature from the beginning, is light, unadulterated wine. It seems probable that a very moderate use of it, at meals, can be indulged in with comparative impunity.

The proportion of alcohol in the many drinks consumed varies greatly. Any beverage containing less than 2 per cent. may be considered as non-intoxicant. Beers average from 3.5 to 5 per cent.; wines from 6 to 15; spirits (whiskey, brandy, rum, etc.) from 40 to 45. Of the latter, pure native whiskey, a few years old, when much of the fusel oil has disappeared and been replaced by aromatic principles, is the least objectionable. The maximum amount of alcohol which anybody can take in health, without immediate apparent harm, is variable; it should never be more than enough to produce a mild degree of temporary stimulation, with no depressing after-effect. This amount for the day should not exceed, as a general average, one ounce of alcohol, or two ounces of whiskey, or ten of light wine, or sixteen of beer. Every prudent man should know what is, for him, a safe maximum dose and never go beyond it, keeping full mastery over this, as well as other dangerous appetites. For many people of nervous, ill-controlled temperament, the only safe rule is complete abstention.

Alcoholism.—Only a few remarks on alcoholism are necessary. The toxicity of alcohol in the blood is mainly due to its dehydrating effect upon cell protoplasm and inhibiting action upon all forms of cell activities, with consequent degeneration of the tissues. The chief effects and symptoms of alcoholism are: congestion of the stomach with increase of connective tissue, degeneration and atrophy of the secreting glands and consequent impaired digestion; congestion and degeneration of the liver, the contracting connective tissue causing atrophy of the portal canals and hepatic cells, a condition known as cirrhosis and generally accompanied by abdominal dropsy; degeneration of the brain substance with motor and sensory

disturbances, accompanied by gradual dulling and failing of the mental and moral faculties; fatty degeneration of the heart and atheromatous or sclerotic condition of the arteries, leading to apoplexy; decrease of muscular energy and capacity for work; failing of the power of resistance to all diseases, the facility with which free drinkers succumb to pneumonia or contract tuberculosis being notorious; it has also been observed that even moderate drinkers contract disease (outside of alcoholism) more frequently than total abstainers.

CHAPTER XXIII.

CLOTHING, UNIFORM AND EQUIPMENT.

The fabrics used to clothe the body are made from animal and vegetable fibers, especially from those of wool, silk, cotton and linen. These fibers are easily distinguished under the microscope (Fig. 71). The wool fiber is cylindrical and covered with imbricated scales; these are sharp and numerous in the best material but worn out in shoddy; they are the cause of the matting together and shrinkage of wet woolen fabrics under pressure. The cotton fiber is flat and twisted, with thickened borders. The silk fiber is a structureless tube without any marking. The linen fiber is a cylinder with cross lines indicating the division of the cells, and occasional filaments at the lines.

The chemical analysis of textile fabrics is difficult and unreliable; an estimate of their relative proportion may be formed by placing them in a 10 per cent. solution of potash or soda; the fibers of wool and silk will be dissolved while those of cotton and linen remain intact (Rubner).

The specific weight of the various materials used for clothing depends chiefly upon their structure, that is to say, the mode of weaving or knitting, their compactness and the quantity of air inclosed in their meshes; thus linen goods having all the fibers in close parallel planes, and smooth surfaces, are the heaviest; woolen flannels, with fibers loosely interlaced in several directions are the lightest, while knit goods are intermediate. As will soon be apparent the qualities and defects of textile fabrics are all closely related to their specific gravity. The following table, from Arnould,* is instructive:

Articles	Specific weight	Volume of interstices per cent.
Woolen flannel	0.101	92.3
Cotton flannel	0.146	88.8
Knit wool	0.179	86.3
Knit cotton	0.199	84.7
Knit silk	0.219	83.2
Knit linen	0.348	73.3
Cotton cloth	0.624	52.0
Linen cloth	0.665	48.9

* Nouveaux élements d'Hygiène de Jules Arnould. 5th edition, revised by E. Arnould.

Furs weigh only about half as much as flannels, containing 95 or 96 per cent. of air.

The general properties of textile fabrics which concern the hygienist are: permeability to air, hygroscopicity, heat radiation, heat conductivity and heat absorption.

Permeability.—Clothing should be permeable to air and allow a free interchange of gases in its meshes, that is to say, sufficiently porous to permit the external air to penetrate to the surface of the body and allow the free escape of the carbon dioxid (CO_2) and sweat (as aqueous vapor)

FIG. 71.—Textile fibers. *a* and *b*, wool fibers; *c*, silk fiber; *d*, linen fiber; *e*, cotton fiber. (*Arnould.*)

constantly excreted by the skin. The lighter and more porous the fabric the greater its permeability, but, with the same fabric, permeability is directly proportional to its thickness. Woolen flannel is the most permeable textile material, and linen cloth the least.

Hygroscopicity.—Fabrics hold moisture in two ways: in the substance of the fiber itself (hygroscopic moisture) and in the interstices or meshes between them (interposition moisture); pressure and wringing can remove the latter but not the former. Hygroscopic moisture swells the fiber to some extent but does not materially impair the permeability of the tissue to air. The capacity of fabrics for interposition moisture depends chiefly upon their texture; thus the maximum capacity of woolen flannel

to fill up its interstices by sweat or rain is only 13 per cent., while that of cotton cloth is 100; in other words, those fabrics capable of holding the largest quantity of water are those that retain it in the smallest ratio and in which, therefore, permeability is least diminished by wetting. Flannel and knit goods absorb moisture, and lose it, much more slowly than cotton and linen cloth. When, after exercise, a woolen garment is put on, the vapor from the body is condensed and absorbed in the fibers; in this process of transformation from gas to liquid, it gives off its latent heat, producing a comfortable feeling of warmth. At the same time the evaporation proceeds slowly and without any sensation of cold.

Heat Radiation.—According to Rubner, the body at rest expends, in a day, about 2,700 calories; of these, 95 per cent. are lost through the skin, namely 1,181 by radiation, 833 by conduction and 558 by evaporation.

Heat radiation is slightly greater for woolen than for cotton goods, and is increased by atmospheric moisture; but the difference between the various textile fabrics is too small to deserve special notice.

Heat Conductivity.—If the conductive power of air be represented by 1, that of wool fiber will be 6, of silk fiber 19, and of cotton and linen fibers 30. The heat conductivity of a fabric will therefore depend upon the nature of its material and the amount of air it contains; flannels and knit goods having the least conductive fibers and the most porous texture will conserve the body heat much better than cotton and linen cloth.

Permeability to air reduces heat conductivity but, on the other hand, favors the loss of heat by evaporation and convection; therefore it must be properly adjusted to atmospheric conditions by varying the thickness or nature of the clothing.

The conductive power of water being 28 times as great as that of air, that of any tissue is necessarily modified by the amount of moisture it contains, especially interposition moisture; wet cotton and linen fabrics, therefore, lose heat much more rapidly than wet woolen ones; they cling to the skin, expelling the protective layers of air between the several garments, and by their rapid evaporation chill the body.

Evaporation.—The evaporation of the sweat and consequent cooling of the surface are favored by permeable porous clothing. In cold weather, when the sweat is reduced to a minimum, the same degree of permeability is not required and more compact clothing can be worn. Evaporation from wet garments depends chiefly upon the temperature and humidity of the ambiant air, but also increases directly with the proportion of water they contain, being greater from linen or cotton cloth than from woolen fabrics.

Absorption.—The heat absorbing power of garments, in the sunlight, depends almost entirely upon their color, white absorbing least; then, in increasing order, yellow, green, red, brown, blue and black, the last-named color absorbing more than twice as much as white.

Having thus briefly summed up the properties and effects of textile fabrics, it is easy to determine those best adapted for underclothing and for outer garments.

Underclothing.

For this are required materials of low conductivity to guard against any sudden or excessive loss of body heat, permeable to air so as to promote the excretion and evaporation of the sweat, and of great hygroscopic power so that the sweat be readily absorbed in the fibers without interfering with the air circulation. The material which best subserves these purposes is woolen flannel, and next to it cotton flannel. Woolen flannel, in contact with the skin, will readily absorb during active exercise in hot weather, 50 per cent. of its weight of perspiration; but this would only fill 10 to 12 per cent. of its interstices, while, under the same circumstances, a cotton or linen undershirt would have 68 per cent. of its air spaces filled up, causing nearly complete impermeability to air and forming a serious obstacle to the evaporation of the sweat, with resulting heating of the body, increase of perspiration and more complete saturation of the undergarments. It is also to be remembered that flannel gives off its moisture by evaporation more slowly than cotton and linen, and cools the skin correspondingly less. Lastly, wool does not retain the organic matter and salts of the perspiration and the sebaceous glands to the same extent as cotton and linen, and therefore is less soiled in the same space of time. Flannel is not only the best fabric for undergarments in winter but also in summer, by varying its thickness.

The chief objection against woolen garments is their irritation of sensitive skins, and their skrinkage and hardening when laundered. Their washing requires special care; it should be done with soap containing but little alkali as this dissolves the natural oil of the fiber and injures its texture; the garments should be immersed and shaken in luke-warm or cold water, rinsed out without being beaten and dried after only very moderate wringing.

Pure wool, however, is not necessary for undergarments; cotton or other material may be advantageously mixed with it to a large extent so long as the flannel or knit structure is preserved.

Silk possesses most of the qualities of wool, being hygroscopic and a poor heat conductor but, in warm weather, gets too easily sodden with perspiration and, in that state, is too good a heat conductor to be a suitable material for underclothing. A combination of wool and silk is the ideal material for the purpose in hot countries, the so-called "Anglo-Indian gauze;" it is more lasting and less apt to shrink than cheaper fabrics of cotton and wool.

Cotton, in the shape of flannel or knit fabric, although inferior to wool for underwear, may take its place when cost is to be considered. Certain cotton fabrics, such as "twilled lining," are much used in India for underwear, shirts and pajamas, being absorbent, easily tolerated by delicate skins and poor conductors. Linen is not suitable for the purpose unless especially woven or knit, and then only for warm weather. It becomes readily saturated with perspiration and requires frequent changes.

Outer Garments.—The nature and thickness of outside garments will depend chiefly upon the temperature of the air. In cold weather, dark woolen fabrics will be best. In warm weather, cotton and linen garments which are better conductors of the body heat, and therefore cooler, are preferable; in color they should be white or nearly so in order to reflect the solar heat as much as possible. Linen goods are smooth and lustrous, heavier and more durable than cotton and of high heat conductivity; they make the best outer garments for warm weather and tropical countries. For out-door work in the tropics, under a blazing sun, the outer garment should not only be white but of sufficient thickness to prevent solar penetration, for, under such conditions, solar heat may readily overcome nature's method of maintaining the body temperature within physiological limits; to prevent this risk, white flannel of suitable thickness is indicated.

Actinic Rays.

Of late years much attention has been paid to the actinic or chemical effects of sunlight upon the body, especially in the tropics (see page 419). They are chiefly produced by the ultra-violet, or short rays of the spectrum, and least active in the red and orange. In order to exclude these dangerous actinic rays, it has been proposed to wear red or orange underwear or to line outer garments and head covering with these colors. As red is more conspicuous and a less durable dye, orange is more commonly used; orange silk being preferable on account of its lightness and non-conductivity. To avoid complexity of garments, Dr. Sambon has devised peculiar fabrics ("solaro" fabrics) with white

warp or outer surface, and black, red or orange weft or under surface. For soldiers, the warp is made of yellow and blue, producing a khaki or drab effect, and the weft of red.

The application of non-actinic colors to the soldier's uniform presents difficulties. Orange or red are too conspicuous to be used as lining to the blouse, or for undergarments in hot countries where the soldier is strongly inclined to discard his outer clothing.

It has been found, however, that opacity of garment is at least as effective as color, and that a black fabric (preferably silk) is altogether best for the purpose. Therefore a black undershirt suggests itself. For the soldier, the best garment would be a "solaro" flannel overshirt, olive-drab outside and black inside. It is especially the head and spine that should be protected against the injurious actinic sunlight of the tropics; hence the necessity of a black lining to the helmet or campaign hat, and of a black band, 6 inches wide, along the middle line of the blouse or overshirt.

THE UNIFORM.

The soldier's uniform must combine various hygienic and military requirements. The proper fabrics having been selected, it should be of such shape and size as to be suitable and comfortable and enable the wearer to perform his duties to the best advantage. Everything must be sacrificed to these primary requirements. It must also be simple, easily put on and removed, and consist of as few garments and have as few detachable parts as possible. All this being granted, there is no reason why it should not also be neat and possess a certain degree of smartness and ornamentation, such as will help to develop in the soldier a spirit of pride in his calling; it is possible that, in our service, not enough importance has been given to the esthetic aspect of the uniform.

In size, the uniform should fit the body, but not too snugly, so that the free movements of the extremities, and those of the chest in breathing, be in no way impeded; it is especially necessary that the neck be not constricted by a tight collar. The layers of warm air interposed between the skin and the clothing should be allowed to escape freely in summer, especially at the neck; but, in cold weather, it may be advisable to restrict this air circulation by tightening the garments at the collar, wrists and ankles. It is important that the trousers and breeches extend well above the navel to protect the abdomen, and be tolerably loose about the seat and crotch to prevent friction and abrasion in marching or riding. In our service, they are held up with suspenders or a webbing waist-belt; the suspenders,

which leave the waist and abdomen free from pressure, are always preferable.

The color of the uniform in garrison is regulated simply by esthetic and hygienic considerations. In the field, it is chiefly regulated by the necessity of being as invisible as possible to the enemy. The visibility of the uniform will depend more or less upon the background against which it is projected, but, under average conditions, white is the most conspicuous color and therefore the most objectionable; then come the following colors in order of conspicuousness: dark blue, scarlet, yellow, green,

FIG. 72.—Dress coat for all enlisted men.

gray and ashy-brown. At dawn and sunset of a cloudy day, as well as by moonlight, white becomes as invisible as gray and brown, blue and scarlet being then the most conspicuous colors. The khaki uniform worn by our men, after being washed becomes pale yellowish-gray and comparatively conspicuous; under the same conditions the olive-drab uniform is nearly completely invisible. For the same reason, all buttons and metal ornaments, as well as articles of equipment, should be of dull material not liable to reflect sunlight.

United States Army Uniform.—In all arms of our Army the enlisted man is provided with only two uniforms: the dress and the service uniforms. The dress coat (Fig. 72) is a single-breasted sack coat of dark blue cloth, fastened with six regulation buttons down the front, with stand-

ing collar and shoulder loops. On occasions of ceremony, cords and tassels of mohair are fastened across the front of it. The dress trousers are of sky-blue kersey (Fig. 73). The service coat is a single-breasted sack coat of olive-drab woolen material (Fig. 75), or khaki-colored washable cotton material (for hot weather), with buttons and collar ornaments of

FIG. 73.—Dress trousers for all enlisted men.

FIG. 74.—Service breeches, olive drab wool, foot.

dull-finished bronze metal (Fig. 76). The service breeches are of the same materials, made loose above but fitting closely below the knee, extending to the tops of the shoes and fastened with tapes (Fig. 74). They are worn with shoes and leggings. For mounted men they are reinforced with a piece of the same material on seat and legs.

The service uniform has now been used several years under various conditions of service and climate, and has proved very satisfactory.

Fig. 75.—Service coat, olive drab wool, for all enlisted men.

Fig. 76.—Service coat, cotton khaki, for all enlisted men.

The Hospital Corps is also provided with a white suit, coat and trousers of bleached cotton duck, to wear when on duty with the sick.

A fatigue suit, coat and trousers of brown cotton duck, is issued to all enlisted men for use when on fatigue work or certain special duties.

The overcoat for all enlisted men is a double-breasted ulster of olive-drab woolen material, suitably lined, extending down the legs 8 to 10 inches below the knee, with standing rolling collar, and closing by means of five large horn buttons (Fig. 77). A hood of the same material, large enough to cover head and cap, can be buttoned around the neck, under the collar, so that when drawn over the head it raises and holds the

FIG. 77.—Overcoat, olive drab wool, for all enlisted men.

collar against the neck; in garrison it is worn only in inclement weather. The front corners of the skirt are provided with buttons or hooks, so that they may be turned back to facilitate marching. This overcoat can be worn over any uniform without change of head-gear.

A blanket-lined canvas overcoat is issued to troops stationed in extremely cold regions, but only for use while on guard duty or in field

service. Mackinaw coats and trousers, of thick navy-blue mackinaw cloth lined with dark-blue flannel, are issued for service in Alaska.

Waterproofing.—Garments, when dry, prevent the loss of body temperature but, when wet, increase it, often to a considerable degree. Thus, wet woolen flannel loses 5/8 more of its heat than when dry, and cotton cloth 7/8. This, as already mentioned, is the result of the greater conductivity of the water which has replaced the air in the interstices of the fabric, the expulsion of the warm layers of air from between the articles of clothing and, lastly, of the greatly increased evaporation.

Furthermore, the clinging of the undergarments to the skin stops the circulation of air upon its surface and, therefore, the excretion and evaporation of the sweat. It follows that wet garments are colder in winter and more oppressive in summer. They also become much heavier, sometimes nearly doubling in weight; thus the overcoat alone will take up 5 or 6 pounds of moisture in an ordinary shower. As a consequence, the burden of the soldier is much increased and his movements impeded.

In view of the extent to which rain may impair the efficiency of the soldier it is very important that his uniform should be rendered waterproof. This, however, must be done without impairing the permeability of the fabrics to air, in this respect assimilating them to the fleece of sheep or the feathers of birds which exclude moisture while retaining a free air circulation. The waterproofing of the uniform in a practical way and with permanent results has not yet been successfully accomplished. In our service, the difficulty has been turned by the issue of impervious ponchos or slickers to enlisted men; but such fabrics add to the weight of the pack and, in hot weather, are exceedingly uncomfortable as there is no escape for the greatly increased perspiration. Experiments, in this country and abroad, have shown that it is possible to treat garments so as to render them rain-proof, or nearly so, not only without sensibly diminishing their air permeability but also without any appreciable increase of weight or alteration in color or appearance. The best preparation for the purpose appears to be that proposed by Cathoire who combines two parts of paraffin with one part of vaseline and dissolves 25 grams of the mixture in a liter of naphtha or benzene. Another and simpler preparation is that obtained by dissolving about 25 grams of lanolin (freed from water) in a liter of benzene; but it has the drawback of being washed off by water and soap and of gathering dust. Munson recommends to soak the cloth in a 10 per cent. solution of lanolin and then pass it through rollers to remove the excess of solution and insure evenness of impregnation.

Underclothing.—According to the necessities of the climate and service,

enlisted men are provided with two kinds of undershirts, wool knit (half wool and half cotton) and cotton knit; two kinds of drawers, unbleached canton flannel (Fig. 78), and jean (Fig. 79); three kinds of overshirts, olive-drab flannel (Fig. 80), heavy and light, and white muslin; two kinds of stockings, woolen and cotton. When the coat is not put on, only the olive-drab flannel overshirt is allowed to be worn with the service uniform.

FIG. 78.—Winter drawers of canton flannel.

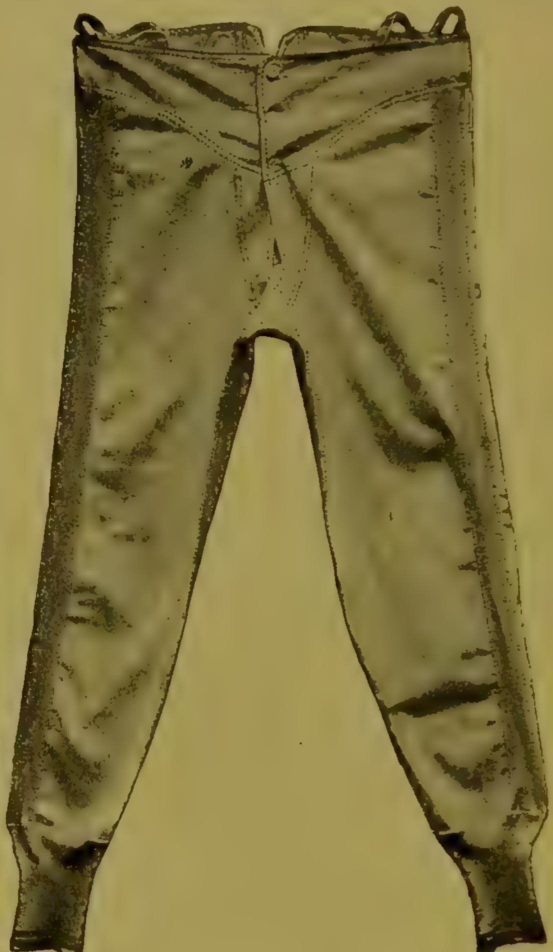


FIG. 79.—Summer drawers of jean.

In Alaska, fleece-lined undershirts and drawers are likewise supplied. A blue-and-white chambray overshirt is also issued, but will be discontinued after the stock on hand has become exhausted. Pajamas have also been removed from the list of clothing.

Head Covering.—The covering for the head should be light in weight, well ventilated and a bad heat conductor; it should also protect the head from heat and cold, shield the eyes in front and the back of the neck from

sun and rain. It should have a firm, even hold of the head so as not to be easily blown off, but without constriction at any point; in other words, it should have the contour of the average head which is oval or elliptical and not circular. Good ventilation is assured by providing plenty of space between the scalp and the top of the covering and a free circulation of air through it. The ventilating holes should be preferably in front and rear rather than on the sides, so as to set the air in circulation by the motion of the wearer. The head-dress, more than any other part of the clothing, must be non-actinic, that is, exclude the short ultra-violet rays; this is best accomplished by black or orange lining, good ventilation and absence of constriction of the scalp.

FIG. 80.—Overshirt, olive drab flannel.

The head-gear which, in a hot country, best combines these requirements, is a properly constructed waterproof pith helmet, with ample brim in front and rear, an all-round ventilated sweat band, and black or orange silk lining. The ideal tropical helmet is one made up of two shells, one within the other, with complete air space between. The use of aluminum or tin-foil is not to be recommended as metals are good heat conductors and interfere with air permeability. Felt or cork may be used instead of pith, but cork, if thick enough, is too heavy. The objections to the helmet, especially for the use of enlisted men, are its bulk, its stiff, unyielding material, and the ease with which it gets broken or damaged, or, if not waterproof, softened by rain. It has been entirely discarded

from our service, although there seems to be no good reason why it could not be used on garrison duty in the tropics and in the Southern States.

Caps.—Enlisted men are provided with a dress cap, two service caps and a service hat. The caps are all alike in shape, having a total depth of 3 1/2 inches, a flat top projecting all around from 3/4 to 1 inch beyond the band, ventilated by two eyelets on each side, and a visor 1 3/4 inches deep

FIG. 81.—Dress cap for all enlisted men.

at its center, slanting at an angle of 45 degrees. The dress cap is of dark blue cloth (Fig. 81) and has a detachable band for occasions of ceremony (Fig. 82) varying in color according to the arm of the service. Of the service caps, one is of olive-drab serge (Fig. 83); the other of cotton khaki with detachable top (for washing), each cap being provided with two tops. These caps take a firm grasp of the head without irksome

FIG. 82.—Dress cap band for full dress.

pressure and are light and comfortable, but do not allow much air space in the flat crown which is sometimes almost, if not quite, in contact with the hair. It is quite necessary, for proper ventilation, that the top be stiffened so that it may not collapse over the scalp and close up the eyelets in each side. Like all caps and kepis they do not protect the nape of the neck.

Campaign Hat.—The service or campaign hat (Fig. 84) is of drab felt, as near as possible the color of the service uniform, practically waterproof, with black or orange-colored lining (in the tropics), a cord to be tied under

FIG. 83.—Service cap for all enlisted men, olive-drab serge.

the chin in case of need, and small perforations on each side for ventilation. Instead of these small perforations, there should be a large one, 3/4 inch in diameter, in front and rear, protected by fine non-rustable wire gauze. It is a very serviceable headgear, protecting also the face,

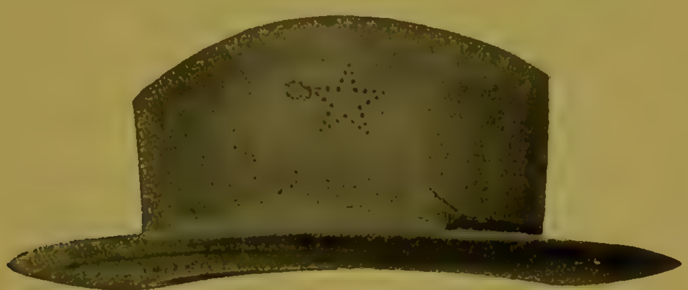


FIG. 84.—Service or campaign hat.

temples and nape of the neck, with larger air space and better ventilation than the cap. This hat would be much more valuable, especially in the tropics, with a corrugated sweat band permitting the air to pass freely

around the head; the advantages of such a band would greatly outweigh the objections which have been urged against it; or, as suggested by Corbusier, a coarsely woven cotton band can be placed inside the thin leather sweat band, next the head, so laced in as to be removable for washing when soiled. Its softness and flexibility allow of rough usage in the field without rendering it unserviceable; in this lies its superiority over the helmet. Creasing the crown reduces the air space and, in hot weather, is not advisable. A wet cloth may be placed within it to cool the head.

In very cold regions, canvas caps lined with olive-drab kersey, which cover the head and neck, may be issued to enlisted men; this takes the place of the former fur cap.

Foot-wear.—In warfare, the chief aim of the commanding general is to occupy advantageous positions with the greatest possible number of men in the shortest possible time. This is largely governed by the marching capacity of the men which, in its turn, depends to a great extent upon their foot-wear, for this, according to Marshal Niel, is to the infantry what horses are to the cavalry. It has been observed in the French maneuvers that, in the first few days, 15 per cent. of the infantry have their feet more or less injured by ill-fitting shoes. In 1883, Von Lindau estimated that, in Germany, there were, each year, 60,000 conscripts exempted from service on account of disability produced by foot-wear. Therefore the importance of well-fitting, comfortable and serviceable shoes cannot be overestimated.

A badly shaped shoe, or one too narrow or too short, produces a misshapen foot and various lesions which seriously impair the efficiency of the soldier (Fig. 85). Most commonly the toes are crowded toward the middle line, the second and third overriding the others, while the big toe is not infrequently partly dislocated at the metatarso-phalangeal articulation which may swell into a bunion. If the shoe is too short to permit the free play of the arch, some of the phalanges become bent down (hammer toes); the foot, whenever losing part of its elasticity, soon becomes cramped and more completely transmits to the body the jars of the step, thus greatly increasing the fatigue of the march.

Before determining the most suitable covering for the foot it is necessary, first, to know something about its anatomical lines. The foot is remarkable for its lack of symmetry from whichever side it is looked at. The planter surface is distinctly arched lengthwise and also, but more slightly, from side to side, a structure which combines strength with elasticity. The arching is greatest on the everted internal border and dis-

appears on the external border which touches the ground. In the standing posture, the foot rests on the heel, the head of the first metatarsal bone (ball of the big toe) and the outside border. In a normal, well-shaped foot, the internal border is practically straight, that is to say, a line drawn from the inside of the heel, along the edge of the middle foot, will pass through the axis of the big toe; or, again, a line drawn along the inner edge of the big toe will touch the inner ankle (Fig. 86). The external border, on the contrary, describes a marked curve, from the tip of the big toe (the longest of the toes) outward along the receding toes, the summit of the convexity being opposite the base of the little toe. The widest part of the foot is an oblique line drawn from the base of the big toe to that of the little toe (ball line). It is to be noted that the ridge of the instep does not run along the middle line of the foot but inside of it and toward the big toe.

FIG. 84.—Radiograph of foot of soldier showing deformity of toes and irritation exostoses due to bad shoes. (*Munson.*)

The shoe is to be made in accordance with these data. The foot should be measured while standing, for the mere weight of the body causes it to spread 1/4 inch in length and nearly as much in width, while, under a heavy weight, such as the soldier may carry in the field, the elongation and widening may reach half an inch. After a long march the whole foot becomes temporarily enlarged. The shoe therefore should be at least 5/8 inch longer than the foot, and wider in the same proportion across the base of the toes. In the tropics, according to Giles, the feet (as well as the hands) become a full size larger than at home.

The sole should be of tolerably thick, resistant, elastic leather, and pro-

ject one-eighth to one-quarter inch beyond the upper; this projection, however, is not so necessary for mounted troops as for infantry and might prevent the foot from freely entering the stirrup. The best shaped sole for a comfortable, serviceable marching shoe is undoubtedly that which follows the contour of the average adult foot. Therefore, instead of a symmetrical rounded tip, with apex in the middle line, the rational shoe should be broadly triangular, with the apex of the triangle opposite the big toe, the internal side slightly slanting inward to the ball of the big toe while the external side is well curved around the toes. In theory, the inner edge of the big toe should be parallel with the axis of the foot, but as

FIG. 86.—The normal foot and foot-print. (*Munson.*)

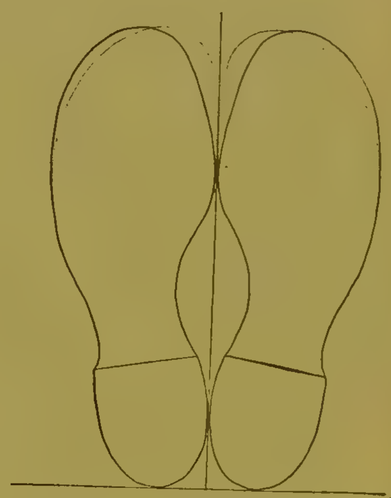


FIG. 87.—Shape of soles of the marching russet shoes issued to enlisted men, the dotted line showing shape of perfectly normal feet.

the adult foot is never perfectly normal in this respect, the big toe being always directed more or less outward, the shape above recommended is practically anatomical. In Fig. 87 the full outline is in conformity with the shape of the average adult's foot, while the dotted outline is that of the ideally perfect foot which is never seen among civilized adults. In the narrow part (shank) of the sole, the concavity of the inside border is more marked than on the outside, corresponding to the everted form of the arch. The split of the upper (if laced), or the seam (if buttoned), should be inside of the median line, so as to correspond to the ridge of the instep. Laced shoes which permit to vary the degree of tightness are preferable.

The heel should be low and broad, and opposite the heel of the foot. The quarter must not be too straight but so curved as to accommodate the

heel and tendon of Achilles without pressure or friction. The two fixed points at which the shoe is secured in close contact with the foot are the instep and the heel; this contact must be firm to prevent slipping and wabbling but not irksomely tight. It is advisable to slightly raise the tip of the shoe to avoid striking stones or sinking in the mud; it is also the position of the toes least fatiguing on the march.

To form a more complete idea of the requirements of foot-wear, we must also bear in mind a physiological peculiarity of the foot, namely its abundant excretion of sweat, the amount poured out by both feet being estimated at one-fourth of the total quantity excreted by the skin surface covered with clothing. The permeability of leather, permitting the evaporation of the sweat, is therefore a desirable quality, especially in hot weather, but this quality only exists to a limited extent and is further diminished by the use of grease. The result is that the perspiration is liable to accumulate inside the shoe and cause soaking and softening of the skin. These drawbacks are reduced to a minimum by the use of laced shoes which leave openings for the escape of the sweat, and of appropriate socks or stockings. Russet-leather shoes, prepared without coloring and polishing, are more porous than black shoes and therefore preferable in summer, or at any time for marching.

The chief object of the shoe is to protect the foot against outside cold, moisture and mud, as well as from injury. Moisture in leather, as in textile fabrics, increases the heat conductivity and, in cold weather, may chill the feet. Waterproofing adds materially to the value of the shoe and comfort of the wearer and, for the soldier, cannot be too highly recommended; no method, however, has as yet been found entirely satisfactory, although, according to Berthier, good results are obtained by treating the sole with a solution of paraffin and the upper with one of lanolin. Greasing the shoe reduces the air permeability of the leather and slightly increases its heat conductivity (although much less than water), but these objections are more than counterbalanced by rendering it more impervious to moisture and keeping it soft and supple. Shoe blacking contains acids which harden and crack the leather. In the field, and in garrison when not required to be polished, the soldier's foot-gear should be cleaned, then oiled or greased. Neatsfoot oil is now issued to enlisted men for the purpose.

Various devices have been recommended to increase the elasticity of the shoe and facilitate marching by the use of rubber in the heel and sole, but none has as yet been found sufficiently practical and durable for military purposes.

In our service, the foot-wear issued to enlisted men of all arms, the result of careful study, is as follows:

1. Garrison russet shoes, laced, with loose tongue, the narrowly rounded tip slightly triangular in accordance with the shape of the toes,

FIG. 88.—Russet shoes for garrison.

the total height from bottom of heel being 6 1/2 inches (Fig. 88). To be used in garrison only and always with leggings or puttees. They are polished with the usual russet dressing.

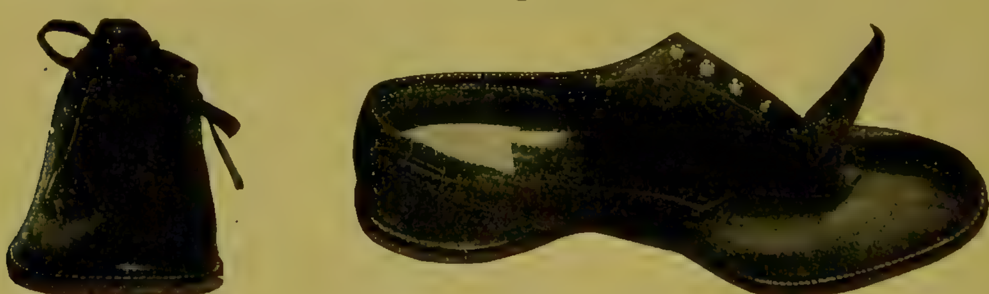


FIG. 89.—Gymnasium shoes.

2. Marching russet shoes, laced, with bellows tongue, more broadly rounded across the toes to give them free play, the sole projecting a quarter-inch beyond the upper. To be used in the field and always with leggings or puttees. They are not polished but oil-tanned with neatsfoot oil.

FIG. 90.—Arctic overshoes.

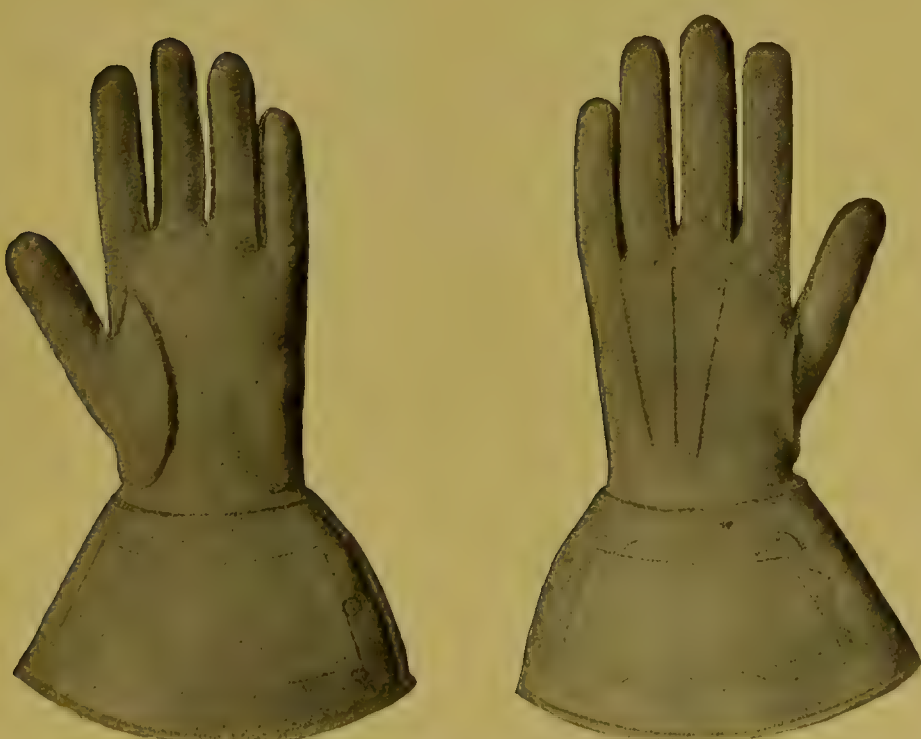


FIG. 91.—Leather gauntlets for mounted men.

3. Black calfskin dress shoes, of exactly the style and shape of the garrison russet shoes.

4. Gymnasium shoes, low shoes of soft black "vici" kid (Fig. 89).

Of dress and russet shoes, fifteen lengths, each length with five widths, or in all seventy-five sizes are provided.

Complaint has been made that these shoes, made upon the usual com-

FIG. 92.—White woolen glove.

mercial lasts, are sometimes too small for their length, no account being taken of the larger development of the military foot in breadth and thickness, so that men are not always able to secure a good fit.

In order to break in a pair of new shoes and mold them to the feet, Munson recommends the following process: Soak them in water until quite soft and pliable; put them on, while wet, over a thick pair of socks and take a long walk; remove them, pack them tightly with oats and set

aside to dry slowly, the swelling of the oats preventing shrinkage of the leather; when dry, rub on several coats of neatsfoot oil.

Overshoes.—In extremely cold regions, when the necessity therefor is certified by the post commander, arctic overshoes (Fig. 90) or lined mocassins may be issued to the men.

Leggings.—Leggings are worn by all enlisted men with the service uniform; of smooth russet leather in the cavalry and field artillery, and of khaki-colored canvas in the infantry, both kinds to be of strap-puttee style, and made in five sizes.

FIG. 93.—Fur mittens, fleece-lined.

Stockings.—Two kinds of stockings are issued, woolen (heavy and light) and cotton. Woolen are in many ways superior to cotton stockings, having greater compressibility, elasticity and absorbent power, and are preferable for the soldier in the field, provided their thickness can be varied according to circumstances. Cotton stockings may be worn in hot weather or when wool provokes abundant perspiration, but need frequent changing.

GLOVES.—The gloves issued are: leather gauntlets for mounted duty (Fig. 91), and white knit cotton or white wool (Fig. 92) for dismounted duty. In very cold regions, leather gloves or fur mittens, fleece-lined, are also provided (Fig. 93). In Alaska, fur gloves may be issued if deemed necessary.

ABDOMINAL BAND.—The woolen abdominal band, formerly highly recommended in the tropics, may be occasionally useful in the case of men predisposed to gastric or intestinal disturbances, but should only be worn at night and when the abdomen is not otherwise suitably protected. It is no longer issued.

EQUIPMENT.

In the field, the soldier, besides the clothing he wears, carries arms and accouterments, ammunition, extra clothing and toilet articles, intrenching tools and rations.

The equipment or "field kit" of the United States infantry soldier is as follows:

	Weight			
Arms and accouterments:	lbs.	oz.	lbs.	oz.
Rifle and sling, with bayonet and scabbard	10	4		
Rifle-cartridge belt and suspenders	1	8		
Haversack	1	8		
Mess-kit in haversack (cup, fork, spoon, knife, meat-can)	1	12		
Canteen, with strap (half-filled)	2	2		
First-aid packet and pouch		5		
Shelter-tent half, with straps	3	5		
Shelter-tent pole and pins	1	4	22	
Ammunition:				
90 rounds rifle ball cartridges	6	12	6	12
Clothing, etc.:				
Blanket	4			
Slicker	6			
(The poncho formerly supplied only weighed 4 lbs.)				
Stockings, pair		3		
Towel		6		
Housewife		4		
Soap, comb and toothbrush		5	11	2
Intrenching tools:				
Wire-cutter (3 per Co.), Hand axe (4 per Co.), Pick-mattock (15 per Co.), Shovel (45 per Co.) — being an average constant weight per man of 1 pound.	1		1	
Rations:				
Two haversack rations (bacon, hard bread, coffee, sugar)	4	2		
One emergency ration	1		5	2
Personal accessories:				
Tobacco, pocket knife, money, etc.		8		8
Total weight			46 lbs. 8 oz.	

Thus it appears that the weight of the equipment is 46 1/2 pounds. If, however, we add the weight of the service uniform and underclothing worn by the soldier (breeches, coat, drawers, shirt, undershirt, stockings, campaign hat, shoes and leggings), namely 12 pounds, the total is increased to 58 1/2 pounds. When weather conditions do not require the infantry to wear overcoats, they are packed in boxes and left at the nearest convenient station. If worn, their weight (9 pounds) must be added to the grand total.

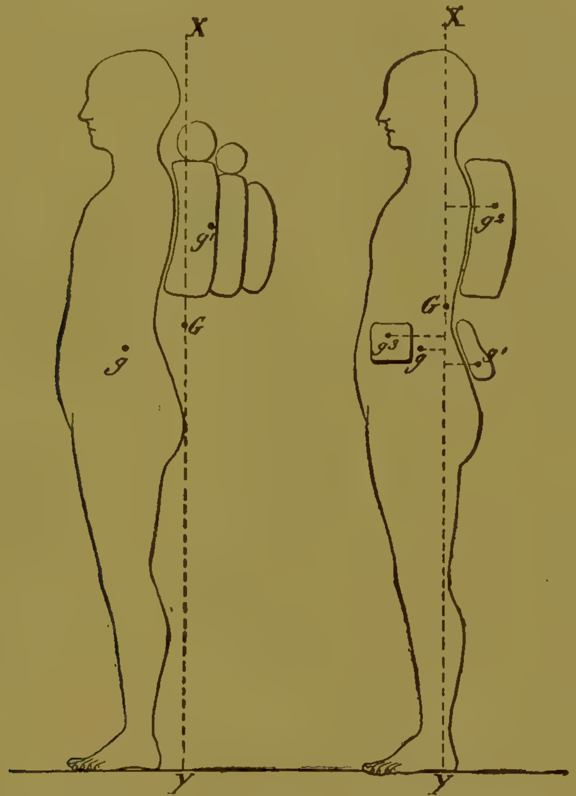


FIG. 94.—Improper and proper methods of distributing the equipment. (*Laveran.*) *G*, center of gravity of body and head; *g*, center of gravity of body.

The men are also provided with a "surplus kit" consisting of 1 pair of drawers, 1 pair of marching shoes, 2 pairs of stockings and 1 undershirt; this is habitually packed in suitable receptacles and carried in the company wagon.

As the command reaches the edge of the fight, the packs will usually be piled and left under guard. Each man after receiving two bandoliers from the ammunition train (120 rounds, weight 9 pounds) will go into action with only arms, ammunition, intrenching tools, water and haversack, in all weighing (exclusive of clothing on the person) about 33 pounds.

To reduce the weight of the equipment to the minimum necessary and

distribute it over the body so as to be most conveniently carried and least impede the marching capacity of the soldier are important questions to which much attention has been given. From experiments carried out in Germany it results that this weight (including overcoat) should seldom exceed 55 pounds. and that a load of 65 pounds is oppressive and exhaust ing and can only be carried a short distance. The weight of the equipment of various European countries ranges from 50 pounds in England, to 64 pounds in Russia. The Japanese soldier carries at least one-half his

FIG. 95.—English field equipment.

own weight in winter. A notable diminution of the French soldier's burden has very recently been obtained by reducing the weight of the knapsack from 16 to 7 pounds, by making the individual mess-kettle, as well as the canteen (with cup attached), of aluminum, and by cutting down the number of cartridges to 88. As stated above, our equipment weighs 46 1/2 pounds without the overcoat, and 55 1/2 pounds with it. Although not very heavy it would be desirable to further lighten it by a few pounds. A reduction seems possible in the overcoat and slicker. By the waterproofing of the uniform, the slicker could be dispensed with.

Distribution of Equipment.—The center of gravity of the body is opposite the second lumbar vertebra and 2 or 3 inches in front of it. The line of gravity is a vertical line passing through this point. The weight of the equipment, to be properly balanced, should be as near the line of gravity as possible and not too far above the center itself. In other words,

Fig. 96.—German field equipment. (*Lavisse.*)

the center of gravity of the load and that of the body should correspond as closely as practicable (Fig. 94). This is best accomplished by distributing the weight around the body over as many points as possible; such distribution has the further advantage to bring all available muscles into play without overexerting any special set. The bony parts which practically bear the entire weight are the shoulders, back and pelvic brims.

They should all be utilized to the full extent. Pressure over the blood-vessels and nerves of the inner part of the arm, in the axillary region, must be carefully avoided; therefore straps and slings passing under the arm should lie close to the body and run in a direction more vertical than transverse. The free play of the chest is most important and nothing

FIG. 97.—Austrian field equipment. (*Lavisse.*)

should seriously interfere with it. It is also obvious that nothing must impede the free movements of the arms, especially in the handling of the rifle.

Knapsack.—The knapsack is an essential part of the equipment of all European armies; it contains spare clothing, toilet and personal articles,

sometimes cartridges and rations. According to Lavisse, it should be made of hide covered with its hair, except on the inner face which should be of pliable leather to avoid heating the back; this inner face should be slightly concave and made to fit the back, thus bringing it nearer to the line of gravity; to secure this fit, 2 or 3 sizes of knapsacks should be

FIG. 98.—French field equipment. (*Lavisse.*)

provided as in the Germany Army. The contact of the sack against the back can be softened by two pads (as in the Swiss Army) which have, besides, the advantage of separating slightly the sack from the back, thus facilitating the circulation of air between them.

The knapsack is suspended by slings from the shoulders according to

various methods, and generally connected by straps with the cartridge boxes carried on the belt in front, so as to balance the weight.

Ingenious and practicable devices have been recommended to support part of its weight upon the hips or lumbar riegon. Of them, the Merriam pack (first suggested by Dr. E. A. Parks, of England) is probably the

FIG. 99.—Swedish field equipment. (*Lavisse.*)

best (Fig. 100): By means of stiff wooden side braces, the main part of the soldier's load is transferred from the shoulders directly to the large bones of the hips. The advantages claimed for this method are the elimination of pressure from the shoulders, entire freedom of motion of the arms and unobstructed ventilation; the abolition of every form of cross belt so that the nerves and vessels of the armpits are wholly relieved from

pressure; the strapping of the blanket, shelter-half and poncho around the knapsack out of the way of the rifle; the suppression of the haversack.

In Europe, this principle of support is only applied in Denmark where the knapsack rests on a strap lifted by a rod which is secured to the belt. Barthelemy, of the French Army, has proposed the use of a cartridge box molded to the curve of the lumbar region and firmly resting upon it, as a support for the sack, a method which, besides, brings the weight of the latter much nearer the center of gravity of the body.

FIG. 100.—Merriam pack.

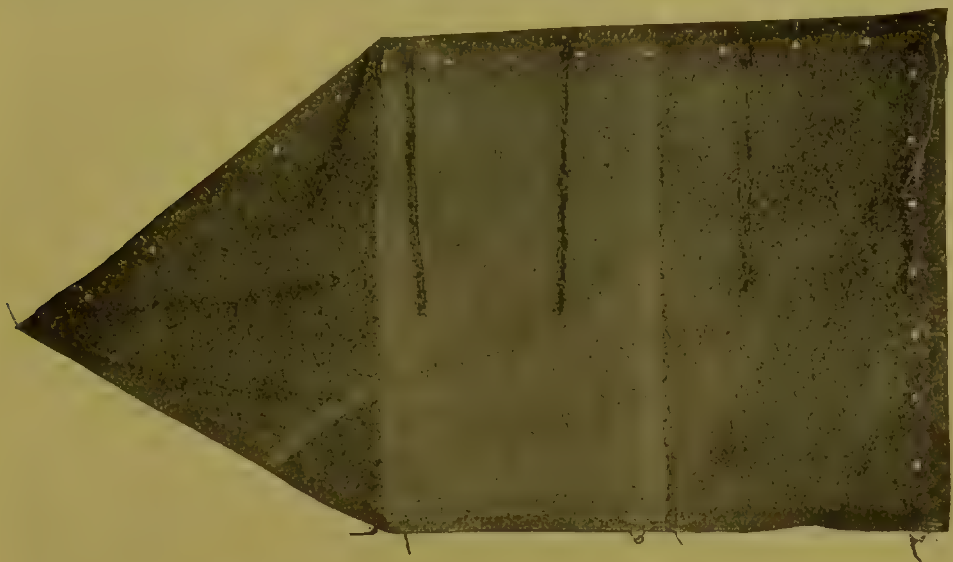
BLANKET-ROLL.—In our service, the knapsack has been entirely discarded and replaced by the blanket-roll (Fig. 101). This consists of the half shelter-tent containing the blanket, slicker, spare stockings, towel, tent pole and pins, and small toilet articles, weighing in all about 16 pounds. The latest model of the shelter-tent is provided with permanently attached straps to secure the roll, thus doing away with a separate set of straps. The roll is bent into a horse-shoe shape, the two ends brought near each other, and slung across the chest over one or the other shoulder (Fig. 102). It is soft and flexible, adapting itself to the surface of the body without friction, easily put on and removed and, when one shoulder is tired, readily shifted to the other. It is also nearer the line of

gravity of the body than the average knapsack and therefore more easily balanced. On the other hand, in warm weather, it heats the neck and

FIG. 101.—Field equipment of the U. S. Infantry soldier.

chest, sometimes to an uncomfortable degree and, if heavy, may somewhat restrain the expansion of the lungs. A more serious objection is that it interferes more or less with the free use of the arms and handling of the

rifle, and that it raises the body, when lying down to fire, a few inches higher above the ground, thus presenting a larger target to the enemy.



Mounted Foot

FIG. 102.—Shelter-tent half, open and rolled.

It must be borne in mind, however, that, whenever possible before engaging in battle, the rolls will be removed and piled.

All things considered, the experience acquired during the Civil War and since, tends to indicate that the blanket-roll, provided its weight does not exceed 15 or 16 pounds is better adapted to our foot troops than any form of knapsack.

CARTRIDGE BELT.—The cartridge belt of the United States soldier is a woven webbing belt 3 1/2 inches wide, with 9 pockets of the proper size to hold 2 clips, each clip of 5 cartridges. Each pocket is provided with a flap

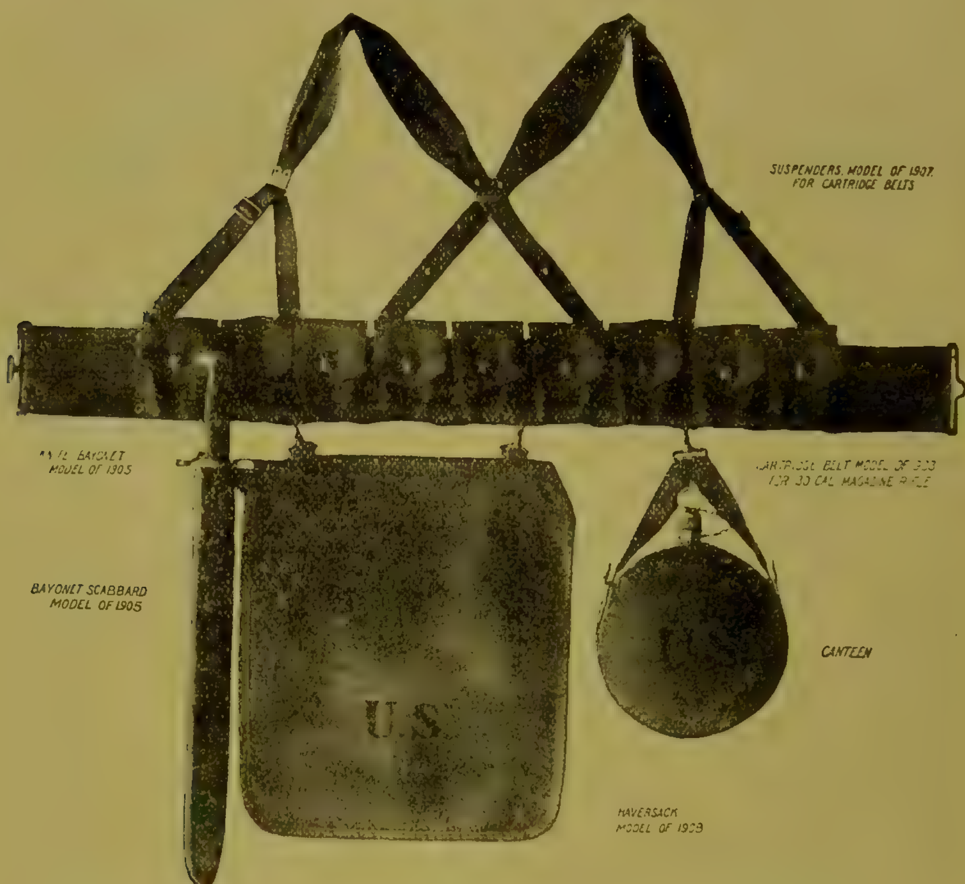


FIG. 103.—Cartridge belt and attachments (first-aid packet omitted).

which closes by a glove fastener. Two metallic eyelets are inserted near both edges, between adjacent pockets (Fig. 103). It is supported from the shoulders by a pair of suspenders hooked into the eyelets of the upper edge. From it, by means of hooks passed into the eyelets of the lower edge, are suspended the haversack, bayonet-scabbard, canteen and first-aid packet (Fig. 104).

HAVERSACK.—The haversack consists of a front, back and flap of khaki duck, with bacon bag, a pocket for fork and spoon, another for the knife,

and bags of white cotton drill for coffee, sugar and salt; a large pocket in the flap contains the meat-can.

CANTEEN.—The canteen is a circular tin vessel, somewhat shaped like a

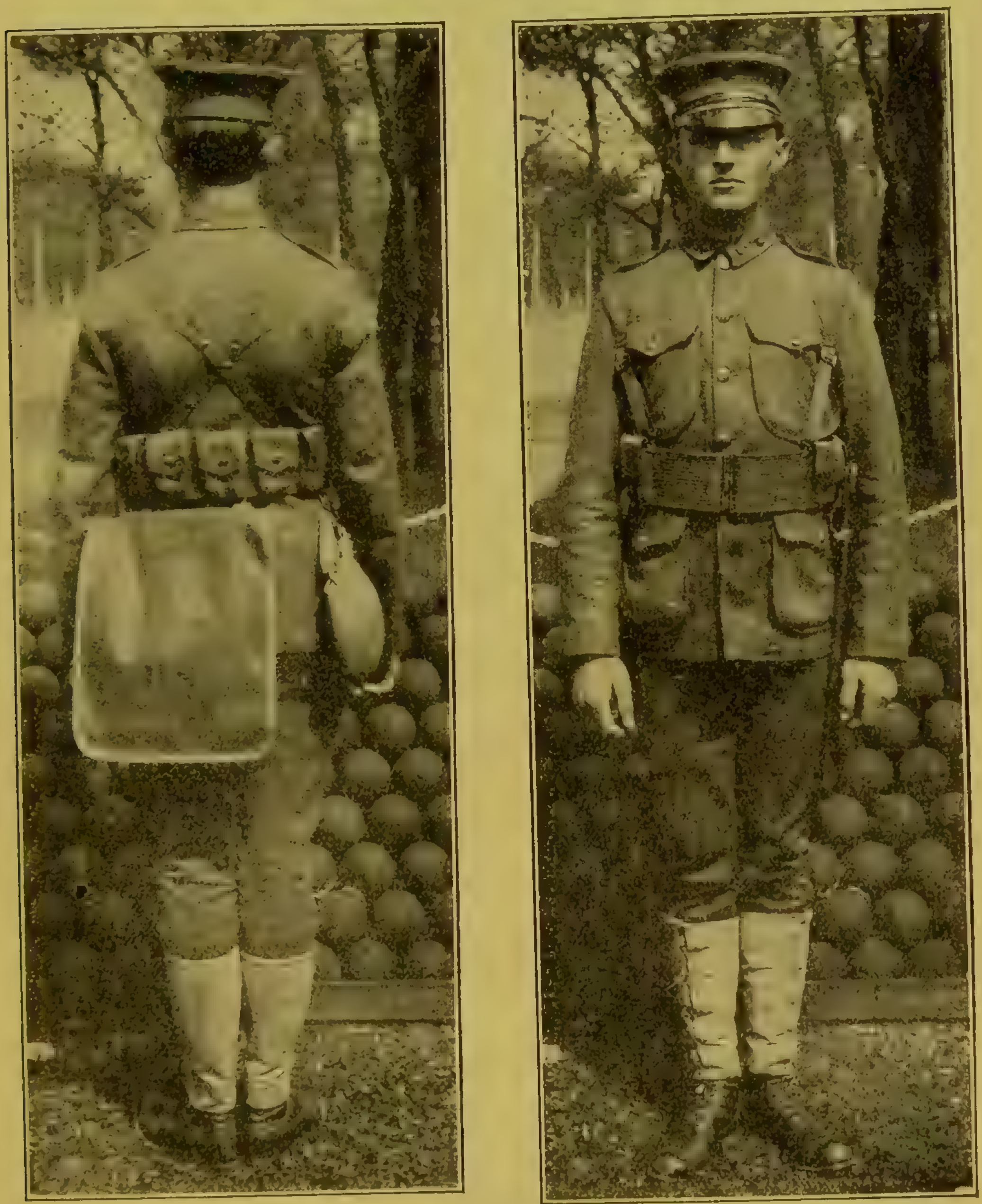


FIG. 104.—Cartridge belt and attachments in position.

double-convex lens, with side toward the body flattened, 8.25 inches in diameter, 2.87 in thickness and holding about 3 pints. It is covered with gray wool felt 0.25 inch thick, and over this with khaki duck. It seems

probable that a capacity of a quart would be sufficient and that the weight could be further reduced by the use of aluminum. The plan suggested by some writers to make the cover detachable, so that the canteen proper could be put into boiling water and sterilized, is neither practical nor necessary.

First-aid Packet.—The first-aid metal-case packet is contained in a pouch of khaki duck hooked to the two central eyelets of the belt in rear, except for mounted troops when it is hooked to the two eyelets on each side of the first pocket on the left.

Conclusion.—In conclusion, it can be said that the cartridge belt and blanket-roll, as used by our troops, have the great merit of evenly distributing the weight of the equipment on the body and to bring it as near the center of gravity as is desirable, with a minimum of irksome and constricting slings and straps.

CHAPTER XXIV.

POSTS, BARRACKS AND QUARTERS.

The site for a military post should be selected with the greatest care, so as to meet not only military but also economic and hygienic requirements. A post should be a model and an object-lesson to the surrounding region in regard to the most approved methods of caring for a large aggregation of men. Therefore no selection of site should be made and no plans decided upon without consulting a competent medical officer. Ample grounds are necessary to prevent crowding of buildings and have plenty of space for formations and drills. For this reason it will seldom be possible to establish a post in or very near a city; such location would, besides, be open to other objections: the noise, smoke and dust of railroads and factories, the allurements of dissipation and the danger of contracting infectious diseases. It is best, therefore, that a post should be well outside of a town, where a sufficiently large reservation can be secured, but yet not so far as to remove it from the many conveniences and advantages which such neighborhood offers. Not only does the vicinity of a town afford to officers and men facilities for general information tending to their greater efficiency, but it is also in the interest of the country that the civilian should become familiar with the military uniform.

From the hygienic point of view, the site of a post should be high and dry, away from marshes, neither on a wind-swept summit nor in a contracted valley where surface waters collect, but rather on gently sloping grounds with good natural drainage, not liable to contamination from any neighboring town, and with sandy or gravelly, porous soil. The ground-water should not be less than 8 or 10 feet deep. Should it be necessary to occupy a low site, with ground-water within a few feet of the surface, thorough underground drainage would be necessary, for there is no medical doctrine better established than that of the detrimental effects of constant humidity upon health. The question of water-supply will require careful consideration. As there are now few places in the inhabited parts of the United States and our colonies where good drinking water in sufficient quantity can be obtained from uncontaminated streams or lakes, it will generally be necessary to provide a purification plant, or else connect the post with the system of a town having such a plant.

The buildings of a post must be so constructed and exposed as to get as much air and sunlight as possible; hence the rule that the interval between them will be at least equal to one and a half times their height. In cold and temperate climates they should face east and west so that they may receive the full benefit of the warm afternoon sun, while in warm countries they should face south and north; but this question of exposure will necessarily be influenced by the direction of prevailing winds, local conditions and architectural exigencies (Fig. 105).

The size, shape and internal arrangements of barracks have been quite variable and, until recently, with but little regard to hygienic requirements. In Europe, where economy of space imposes itself, they are mostly large, several-storied, monumental structures, each accommodating a battalion or even a regiment; they generally suffer from serious hygienic defects and have often been unduly crowded, with consequent high mortality. During the last thirty years a strong reaction has manifested itself in favor of smaller barracks, especially of separate 1-story pavilions, and the health of troops has much improved in consequence. In France, for instance, the Tollet pavilion has been introduced in several garrison towns. It is a simple structure of brick and iron, 27 feet wide and 25 high, unceiled, with ogival roof, and ventilated through the ridge. Its claims are: that it separates men and organizations and reduces the chances of communicating disease, diminishes as much as possible all infectible and putrescible material, renders all surfaces impervious to germs and vermin, suppresses angles and furnishes a maximum of enclosed air with a minimum of enclosing surface, favors natural ventilation, and relegates all services likely to compromise health (kitchens, laundries, latrines, etc.) to outside places. It has become obvious, however, that such a system demands too large areas and scatters the command to an inconvenient extent. It has been given up in continental Europe, but the English appear to be still in favor of it. Experience has demonstrated that in temperate as well as in tropical climates, barracks of two stories are fully as hygienic as 1-story pavilions, besides being less expensive of space and money, and more easily administered.

Each company, troop or battery should have its own separate barrack, kitchen and mess. In order that they may receive as much light and air as possible, barracks should be parallel to one another and, if the terrain permits, in echelon; that is to say, each one projecting more or less beyond the last. The disposition in squares or quadrangles is very objectionable, as one or more sides, as well as the enclosed court, will be shut off from the sunlight and prevailing breezes; were such an arrangement

FIG. 105.—Fort Ethan Allen, Vermont. Post of Modern Construction, Showing Arrangement of Buildings. 1, Commanding officer's quarters; 2, officers' quarters; 3, guard house; 4, barracks; 5, band quarters; 6, saddler shops; 7 hospital; 8, non-commissioned staff quarters; 9, cavalry drill-hall; 10, cavalry stables; 11, post exchange; 12, bakery; 13, store-house; 14, store-house; 15, scale-house; 16 forage-house; 17, shops; 18, ordnance; 19, fuel shed; 20, oil-house; 21, magazine; 22, water tower. (From *Munson.*)

rendered imperative by local conditions, a wide interval between adjoining buildings should be left at the four corners.

Construction and Materials.—The property of building materials which most concerns the hygienist is porosity, that is to say, the amount of air they contain. From this depend their heat conductivity, moisture capacity, air and water permeability. Since air is a worse conductor than any liquid or solid substance, the more porous a material the lower is its heat conductivity and capacity; in other words, the more easily are its surfaces warmed, but the more slowly does heat penetrate through it. Walls of such material will absorb but little sunheat and lose but little of the inside artificial heat, therefore will keep a building cool in summer and warm in winter. Another property they possess is bad conductivity to sounds.

The above qualities of porous materials are necessarily modified by moisture, according to the quantity of air which is replaced by water; they become better heat conductors and lose more or less of their permeability; the larger the pores the less is the increase of conductivity and loss of permeability, and the quicker do they dry after a rain.

The permeability to air of building materials has sometimes been considered a valuable factor in the ventilation of buildings. But the researches of Lang and Recknagel have demonstrated that the amount of air capable of passing through the most porous of them is practically insignificant and a negligible quantity with regard to the renewal of air and ventilation of rooms, especially when the walls are plastered, painted, or paper-covered.

Brick are light, cheap, durable and porous, and, for these qualities, very generally used. Their marked porosity makes them a bad heat conductor. Thus a brick wall 10 inches thick will protect as efficiently against external variations of temperature, in a moderate climate, as one of limestone 20 inches thick (Arnould). It must be borne in mind, however, that to prevent the transmission of solar heat into a building, a wall, of whatever material, must have sufficient thickness; thus, a brick wall only 12 to 15 inches thick may become so heated in the day that it only partially cools off at night, and its temperature will continue to rise from day to day until its internal surface is reached. The use of perforated brick in walls, at least for the inside course, adds very much to their non-conductivity and is therefore highly desirable in all climates. In tropical countries, it is a further advantage to build double walls with an air space of 2 to 4 inches between them; this space should be provided with screened outlets for the free escape and renewal of air.

The porosity of brick renders them quite permeable to air, especially under the pressure of a strong wind. They are also very absorbent, taking up 10 to 20 per cent. of their volume of water. For these reasons, brick walls should always be plastered, at least inside, and unless otherwise protected from rain it is often advisable to paint them outside; nor should they ever be in direct contact with the soil.

Stone, especially marble, hard sandstone, granit, etc., is less porous than brick and a better conductor of heat; it absorbs less water but retains it longer; on the other hand, it is more durable and sightly.

Wood is a very poor conductor of heat and affords efficient protection against the sun, but is very hygroscopic, moisture causing it to expand irregularly, with disjunction of parts, cracks and fissures leading to decay and favoring the collection of dirt and parasites. It is, besides, always in danger of fire.

Iron, now so largely used for the framework of buildings, is an excellent conductor of heat and sound; but this defect is mitigated by a sufficient covering of stone or brick and mortar. It has the advantage of being impenetrable to humidity.

Ordinary mortar, consisting of lime, sand and water, is very porous, especially when made with coarse sand. Plaster is still a poorer conductor of heat than mortar, although less permeable; it is the most hygroscopic of materials. Cement and concrete are waterproof and have little porosity and permeability, therefore are good conductors of heat.

A new building contains a large proportion of water, from 130 to 230 liters in a cubic meter of brick masonry, according to Flügge. Such excessive humidity must be gotten rid of before it is habitable. In a damp building the cutaneous evaporation is checked, while the loss of body heat by radiation and conduction is increased; it follows that the occupants are unduly overheated when the temperature rises, and chilled when it falls. Furthermore, damp walls being better heat conductors, the building is difficult to warm in cold weather, or becomes overheated by the sun in hot weather. For these reasons, confined dampness has an unfavorable influence upon human health, leading to catarrhal and rheumatic affections as well as to tuberculosis. No plastering or coating of any kind should be put on the walls until they are quite dry, that is, until the mortar, which in the fresh state contains 15 per cent. of free water, has dried down to 2 per cent. or less. Plaster contains nearly twice as much water as mortar and dries very slowly. It is readily seen, therefore, why a newly completed house should be thoroughly ventilated and gradually heated,

at least for a week or two, according to the weather, before it is fit for occupancy.

Cellars and Basements.—Cellars and basements improve the healthfulness of buildings, provided they are properly constructed. Unless they are impervious to ground-air and water they do more harm than good. Ground-water may rise into them or keep the floor and walls constantly damp; ground-air, more or less polluted, readily escapes into them and, as it becomes warm, ascends into the building carrying more or less humidity with it. Even under the best conditions, air moisture readily condenses

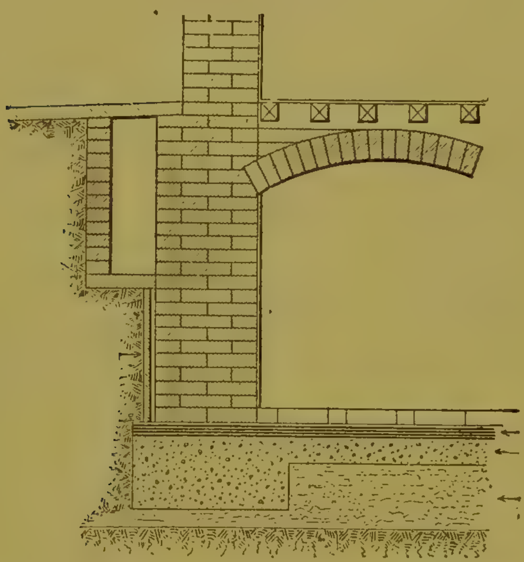


Fig. 106.—Method of flooring cellars to prevent dampness. *a*, Disconnected air-space lined with cement; *b*, asphalt; *c*, concrete; *d*, clay. (*Munson.*)

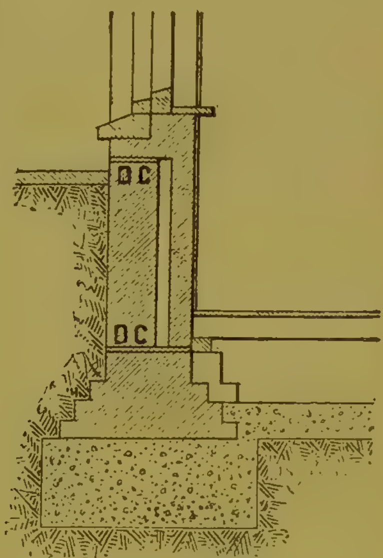


Fig. 107.—Method of preventing dampness of walls. Letters D C denote location of damp-proof courses. (*Munson.*)

on the cool walls of a cellar, and unless well ventilated or artificially heated it will seldom be perfectly dry. It is necessary therefore that cellars and all other substructures should be made impervious. Damp grounds must be underdrained. The floor should be covered with a layer of concrete coated over with cement or asphaltum. A more perfect result is attained by placing the concrete over a stratum of well-tamped clay.

Foundations.—The best material for foundations is stone. Their most important hygienic requirement is that they be waterproof. Therefore, besides being drained, they should rest on a bed of impervious concrete (concrete footing) and be protected from outside moisture by layers of tar and cement (Fig. 106), or by a trench extending down to the

footing and filled with broken stone. A double foundation wall, with air space of 2 or 3 inches, is also very useful in preventing much of the outside moisture from reaching the internal surface (Fig. 107). The space may be loosely filled with a non-hygroscopic material, such as cinders. In order to preclude the rising of moisture into the walls by capillary attraction, it is also necessary to interpose, at the level of the soil, a "damp-poof course," consisting of slates, vitrified bricks or water-proof felt imbedded in cement or asphaltum.

Barracks and other buildings without basement or cellar should be raised above the ground, leaving a clear air space beneath, large enough, if possible, for inspection and cleaning. A further improvement would consist in cementing the floor of this space.

PLASTERING.—Walls may be furred, lathed and plastered, with an air space of about 2 inches between the brick and lathing materially contributing to their dryness and non-conductivity. The use of perforated brick for the inside course, now becoming general, renders lathing unnecessary; such brick furnish a sufficient air space and are of equal hygienic value, without providing a harbor for rodents and vermin. Plaster may also be applied upon a wall of solid brick by the intervention of a thin coating of adhesive material, but this is clearly undesirable.

Partition walls should preferably consist of large hollow tile, of light, incombustible material, non-conductor of heat and sound; such walls are readily plastered without the intervention of any other material.

Ordinary plaster is porous and absorbent, and therefore a poor material for the inner finishing of the walls of barracks or any building occupied by a number of men. The vapor of respiration, with its organic matter, condenses upon it and all the impurities floating in the air readily adhere to it. It should be whitewashed or kalsomined at least once a year. Much preferable, however, is the use of a harder, less porous material, one that can be readily washed, such as adamant plaster, soap-stone finish, good oil or enamel paint, etc. Where a certain degree of ornamentation, together with more complete asepsis are desired, as in bath-rooms, operating rooms, etc., enameled or vitrified tiles of various types are used.

FLOORS.—The ideal floor, in temperate and warm countries, is a hard, smooth, impenetrable mineral floor, free from open joints and crevices, one that can be washed and scrubbed without danger of dampness, decay and shrinking, and that affords no harbor of refuge to vermin and dust. But the expense and weight of such floor render it too often prohibitive; it is also open to the objection of being uncomfortable in cold weather.

The material most used for flooring is wood. It should be laid in two layers, with a thickness of flooring felt between, the lower of boards laid diagonally, close together, and the upper of tongued and grooved boards. For lavatories, latrines and other places whose floors need frequent washing, an impervious material is necessary, such as cement, asphaltum, "terrazo" (made of small pieces of marble laid in cement and smoothed down), or various types of mineralized wood pulp for which are claimed the combined advantages of wood and stone. In tropical countries, tiles or marble slabs laid in cement make perfect floors.

Between the floor above and the ceiling below, there is often an empty space. This is an advantage as it deadens sounds and prevents heat conduction. It is essential, however, that it should not become a receptacle for organic matter passing through the cracks and defective joints of the flooring, and liable to be stirred up by air currents and contaminate the air of the room above. This is rendered impossible with a tiled floor properly laid in cement, or a wooden floor resting on a ceiling of hollow tile or reinforced concrete, especially if imbedded in asphaltum.

But the organic dust, full of micro-organisms, which constantly accumulates on the wooden floor of inhabited rooms, especially barracks, finds lodgment in the joints, cracks and all interstices, however minute; it is constantly raised by air currents, as well as by sweeping and dusting, and a menace to the occupants. Furthermore, any moisture applied to an unprotected wooden floor will cause it to expand, crack and decay. Hence the necessity of filling and closing up all places capable of harboring dust and vermin, and to render the wood impervious to water. Coal tar, diluted with heavy coal oil, has long been used for these purposes in French barracks, but lately was replaced by carbonyle (coal-tar product) which, besides rendering the wood impermeable, possesses also bactericidal and parasiticidal properties; it has the objection of imparting a dull brownish tint to the floor. In German barracks, boiling linseed oil is used once or twice a year, but although undoubtedly useful fails to fill up the joints and cracks. The use of paraffin and wax gives excellent results but is too expensive for general application. Certain coal-oil products, cheap and easily applied (such as the *Standard Floor Dressing*) are reported to be very satisfactory.

In our barracks, all finished wood floors and stair treads are given one coat of raw linseed oil, well rubbed in, and nothing more. It is evident that the importance of rendering them impermeable to water and safe against the accumulation of dust is not sufficiently appreciated.

WINDOWS.—Windows should extend up within a short distance of the

ceiling, and down to about three feet of the floor. In cold and temperate climates it is best that the two sashes slide vertically one over the other, ventilation being thus more readily graded; in warm countries, French windows descending nearly to the floor, with sashes hinged at the sides and opening laterally the whole width of the aperture, are preferable. An excellent combination is to have an independent transom over the French window, to be used for ventilation when the weather does not admit of the opening of the window itself. Doors and windows must be protected by suitable screens against flies and mosquitoes whenever these insects are troublesome or the diseases which they convey are prevalent. In cold countries, double windows are used so as to save heat and prevent drafts; in such case, the outside window should always have a ventilating panel which can be opened or closed to the desired extent. In northern European countries, the lower part of the space between the two windows is often filled with wool, a device to be commended only when the temperature remains long below zero.

Roofs.—For most countries, slate laid on heavy builder's paper is the best roofing material. Tiles are less conductive, therefore cooler and better adapted to hot climates. Metal roofs become very hot and are therefore objectionable unless they rest upon a layer of coarse cement. When an emergency requires the use of corrugated iron or other metal, it should be laid in two layers separated by an interval of six inches. In tropical countries, it is well to provide an air space, or attic, between the top floor and the roof, and, between this attic and the tiles, to interpose a layer of porous cement laid between and over the rafters, consisting chiefly of some non-conductive substance (cinders, infusorial earth, pozzuolana, etc.).

General Specifications for United States Barracks.

In accordance with the specifications of the Quartermaster General's Office, our barracks are two-story and basement brick buildings; the exterior basement and area walls and piers, of stone; the footings under all walls, piers, chimneys and iron columns, of concrete; the superstructure, interior basement walls and all chimneys of brick; the roof of building to be covered with slate, and the roofs of porches, of tin.

A subsoil drain of 6-inch vitrified, hub-joint, terra-cotta pipe is laid outside of the footings, the lower third of joint cemented and the remainder left open. Through 2-inch cast-iron pipes, it receives the drip from refrigerators and drainage from area ways. It has no connection with the sewer.

The downspouts are of corrugated galvanized steel, provided, below the water table, with cast-iron, hub-joint leaders which connect with a 4-inch vitrified terra-cotta drain emptying into the main drain or wherever desired, but not connecting with the sewer.

The entire basement floor (including toilet rooms, barber and tailor shops) is properly filled, graded and rolled to a firm surface, then covered with 4 1/2 inches of concrete; before this has set, a finishing coat, half-inch thick, of one part cement and two parts sand is put over it. The floors of toilet rooms and shower stalls are graded from walls to floor traps. The steps, coping and floor of each area-way likewise receive a layer of concrete and finishing coat.

The stone work must be of sound, durable local stone, of good quality of rubble work, faced full height on inside, and below grade on outside, the

FIG. 108.—Standard barrack. U. S. Army. Front elevation.

mortar used consisting of one part cement and three parts sand. After basement walls are well set and dry, the outside, from bottom of footings to surface of ground is to be plastered half-inch thick with mortar composed of equal parts of cement and sand.

No damp-proof courses are used except in exceptional cases.

The brick must be sound, hard, well burned and dark-red common brick, laid with flushed, solid joints; dry if laid in frosty weather, and well wetted if laid in dry, hot weather.

The floors consist of two layers: the under layer of boards not over 8 inches wide, dressed on upper side and laid diagonally, close together, upon the wood joists; the upper layer, of maple or yellow pine boards, tongued and grooved, 3 1/4 inches wide, tightly driven up and blind nailed; with one thickness of flooring felt between them (no tarred paper used).

The hand rails are of oak throughout; the stair treads of same wood as

upper floors; all other inside finish of best quality of white pine or yellow poplar.

The entire halls of basement, first and second stories are wainscoted four feet high, with baseboard and cap moulding. All rooms in first and second stories have baseboards, with moulding at bottom.

All walls and ceilings (except ceilings of first story and soffits of all stairs) are furred, lathed and plastered; the plastering consisting of three coats, the first two of quick-setting cement plaster, the third, or finishing coat, of hard white cement-finish troweled to a smooth surface. The stone walls in toilet rooms are given a coat of plaster made of one part of Portland cement and three parts of sand applied directly to the stone and floated smooth and even.

All ceilings of first story and soffits of all stairs, on account of the great jarring to which exposed, are covered with one thickness of heavy flooring felt and then cross-furred with strips properly spaced to receive steel-ceiling plates. These plates, about 20 inches square, have lock slips or countersunk joints with no ornament of any sort except in extreme corners to conceal wrinkles.

All roofs of building (except where tin is specified) and the walls of dormers are covered with the best quality of unfading black slate. Before laying the slate, the roof is covered with a thickness of best red-rope, waterproof sheathing paper, free from wood pulp and rosin. The roof of all porches is covered with tin, in locked and soldered plates, laid on one thickness of flooring felt.

All outside wood and metal work (except copper and tin) are painted three coats of paint made of white lead mixed with linseed oil, the last coat to be one-third zinc white. Tinwork receives one coat of mineral paint on under side and two on upper side. All interior woodwork and exposed iron columns are painted three coats of paint made of equal parts of white lead and zinc white mixed in linseed oil. The walls of each toilet room receive two coats of lead and oil paint and a third coat of white enamel paint.

Uses of Rooms.—The basement and two stories of barracks are generally assigned to the following uses as shown in Figs. 109, 110, 111. In the basement is the lavatory, containing water-closets, urinals, wash-bowls, laundry tubs, 4 to 6 showers and one bath-tub. On the first floor is the kitchen, with pantry, store-room and cook's room; mess-room; company office, with adjoining store-room and clerk's room; a large recreation room; first sergeant's room; one dormitory. On the second floor are only dormitories, with separate rooms for non-commissioned officers.

FIG. 109.—Standard barrack, U. S. Army. Basement plan.

FIG. 110.—Standard barrack, U. S. Army. First floor plan.

This arrangement is entirely satisfactory. The location of the lavatory in the basement, assuming that the plumbing is perfect, is quite unobjectionable; it is of convenient access and is heated in the easiest and most economical way possible. The kitchen and mess-room are properly placed on the first floor, the kitchen in a wing and the mess-room in the main building; a large hood over the hearth carries off all odors so that none are detected in any other part of the barrack. It is a recognized principle in hygiene that dormitories should be as high as possible above

FIG. 111.—Standard barrack, U. S. Army. Second floor plan.

the soil; it is therefore one of the advantages of a 2-story barrack that the upper floor can be exclusively used for dormitories.

Sometimes lavatories are detached (Fig. 112), each being placed in rear of its corresponding barrack. This may be rendered necessary by the difficulty of getting a suitable outlet for the excreta and wastes at a lower level; but, all things considered, it is less desirable than a properly installed basement lavatory. When thus detached it generally contains the barber shop and tailor shop.

Several of our large posts are provided with general messes, that is to say, with one common kitchen and mess-room for the several organizations

of the garrison. Such messes have decided advantages, provided they are managed by competent and interested officers; they are more economical, admit of a higher grade of cooking, are more easily supplied and their

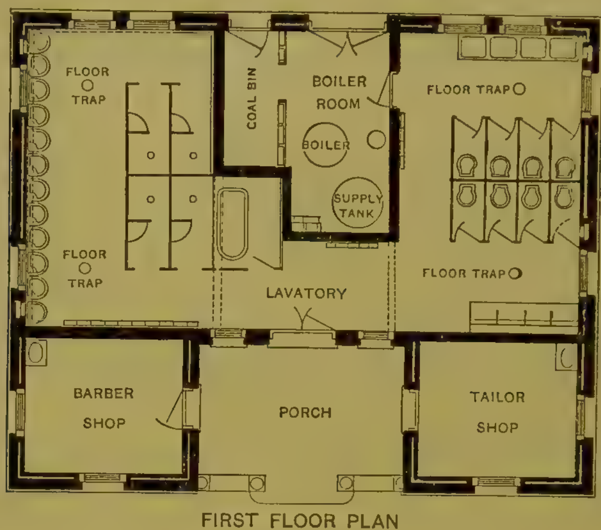


FIG. 112.—Detached company lavatory.

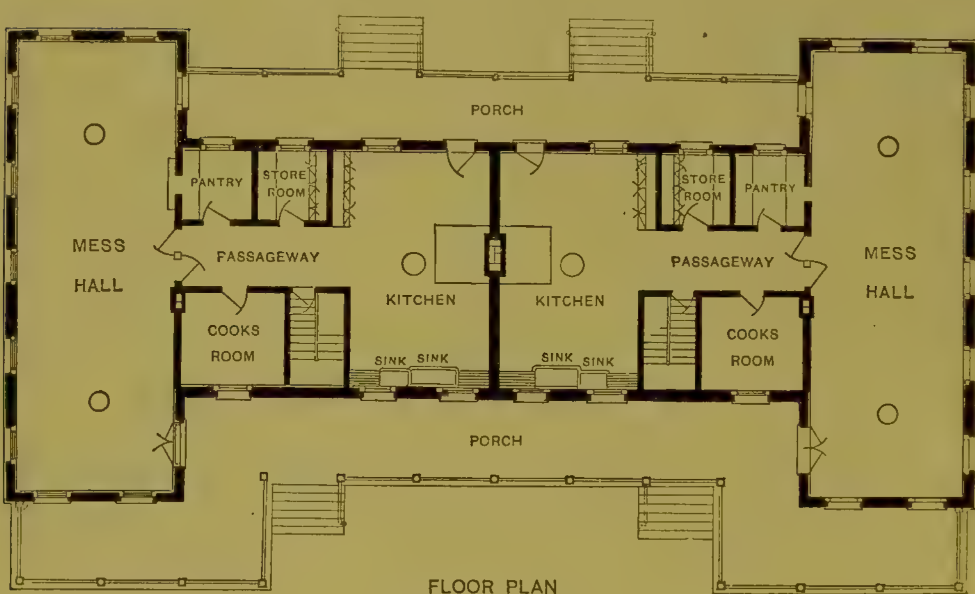


FIG. 113.—Double company kitchen and mess hall.

wastes more readily disposed of. Notwithstanding all this, there is a general opinion that separate company messes are preferable, inasmuch as each company trains its own cooks and is always ready to take the field independently. Besides, companies may thus benefit from the careful

and thrifty management of their officers and indulge in such delicacies as their resources permit.

When barracks are so planned that kitchens and mess-rooms have to be detached, a very convenient and economical arrangement is that illustrated in Fig. 113, in which two sets are contiguous and under the same roof. This is particularly suitable for barracks disposed in double sets.

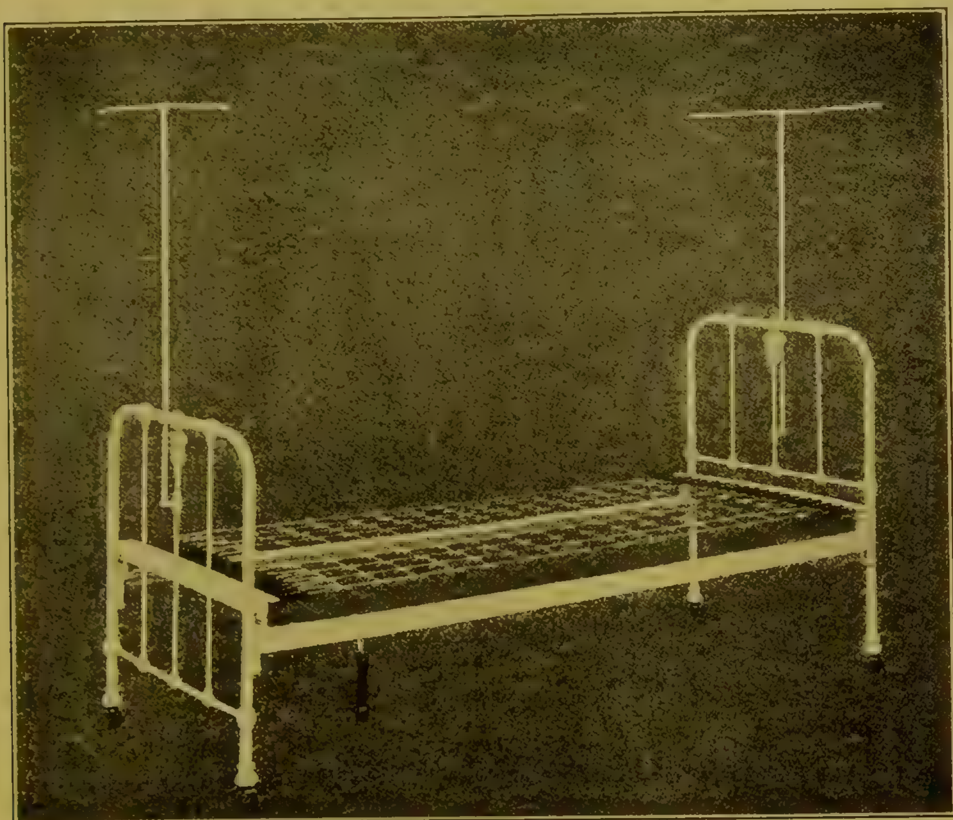


FIG. 114.—Barrack bedstead.

The features which should characterize barracks in the tropics are described in the chapter on *Service in Warm Climates*.

Furniture and Bedding.

All woodwork and furniture in barracks should be of the simplest kind and easily accessible, with as few recesses, angles, mouldings, projections and open shelving as possible to avoid the accumulation and dissemination of dirt and dust.

Wainscoting is superfluous and harmful in barracks, affording refuge to vermin and rodents.

The bedstead now provided for enlisted men is above criticism. It is entirely of metal, the link-meshed spring bottom, or "fabric," being 9 meshes wide by 16 meshes long, in all 65 inches long and 31 3/8 wide, and connected to rail at each end by 19 spiral springs. Head and foot pieces have mosquito-bar rods (Figs. 114).

The bedding consists of mattress, mattress cover, pillow, pillow cases, bed sacks, pillow sacks, mosquito-bars, sheets and blankets. The mattress consists of narrow-stripped blue and white ticking filled with one unbroken sheet of interlaced carded cotton felt (Fig. 115). For protection it is enclosed in a cover of unbleached cotton duck. The pillow is made of the same material, and enclosed in cases of unbleached muslin. The bed sacks, of unbleached cotton drilling, and pillow sacks, of unbleached cotton duck, are intended to take the place of mattresses and

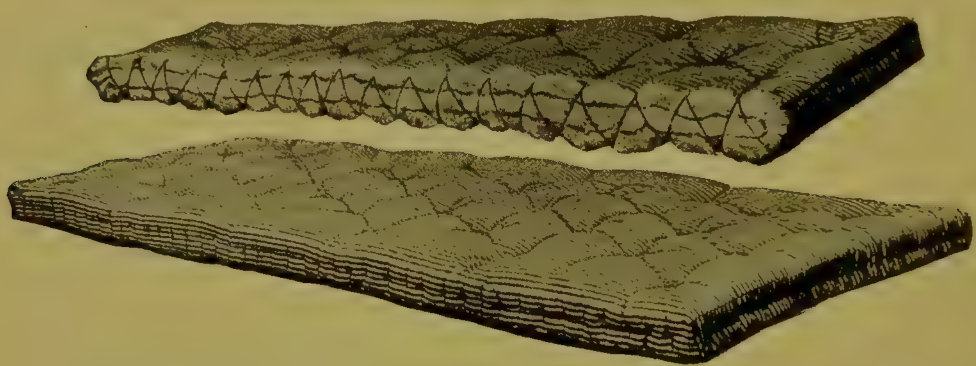


FIG. 115.—Mattress of felted cotton, for use with barrack bedstead.

pillows in the field, stuffed with hay or grass. Mosquito-bars are indispensable in garrison and field, wherever malaria and yellow fever prevail, and stringent orders should be issued to insure their proper use. The sheets are of unbleached sheeting, 90 inches long and 48 wide. The blankets are of two kinds: 1, heavy, olive-drab woolen blanket, 7 feet long, 5 1/2 feet wide, weighing 5 pounds; 2, light olive-drab woolen blanket with cotton warp, of same size, weighing 3 pounds (for use in warm countries).

The bedding soon gathers dirt and dust from the body, clothing and surrounding objects; it should be taken out, well shaken and sunned a few hours once a week whenever the weather permits.

All soiled clothing is placed in a "barrack bag" of brown cotton duck, 32 inches deep and 15 in diameter (Fig. 116).

Lockers.—Each enlisted man is supplied with two lockers, a "metallic wall locker" attached to the wall and a permanent fixture of the squad-

room (Fig. 117), and a "trunk locker" which he carries with him whenever changing station (Fig. 118).

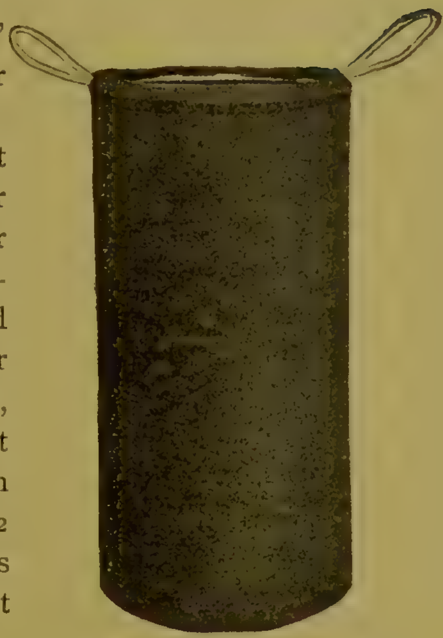


FIG. 116.—Barrack-bag.

The wall locker is constructed of sheet steel, varnished and finished in oak or olive green; 7 feet 4 inches high in rear but only 6 feet 8 inches in front on account of sloping top; 19 inches deep and 20 inches wide (when single). The door is perforated for ventilation by 12 slots, with hood to prevent the settling dust from getting to the contents. Eleven hooks are provided, 3 in each wall and 2 double ceiling hooks, all triple brass plated. These lockers may be single but are generally double, treble or quadruple.

The trunk locker is a rectangular box 30 inches long, 16 inches wide and 12 inches deep, inside measurement. It has a tray 2 3/4 inches deep, divided into 3 equal compartments. It is made of wood in 3-ply veneer, with outside covering of vulcanized hard rubber bound on the corner edges with vulcanized fiber and clamped at the corners.

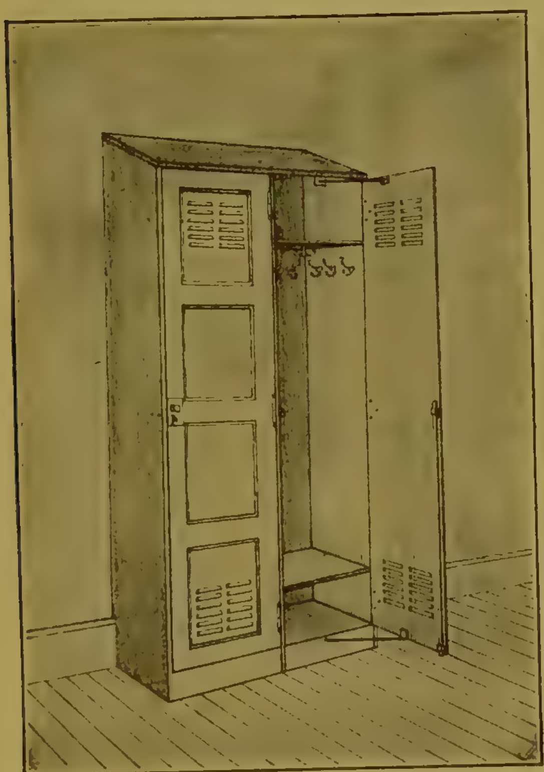


FIG. 117.—Metallic wall locker, double.

Bedbugs are not only the most noisome and troublesome of the insects infesting barracks but are also probably capable of conveying disease. Therefore every effort should be made to exclude them, or to exterminate them after their invasion. The frequent examination of the bedding and clothing is necessary, as well as of the linen returned from the wash. They are destroyed by subjecting all infested clothing and bedding to the action of steam under pressure in a large disinfecting chamber, or

boiling them in water. An emulsion of petroleum (1 to 3 or 4 of water) may be applied with a stout brush, or else a spray of benzene or gasoline, in the cracks of the woodwork and bedding. A saturated solution of corrosive sublimate is efficacious but cannot be applied to metals. Insect powder is useless; it has only a stupefying action upon the insect and no effect upon the eggs. If a whole barrack be infested, thorough sulphur fumigation is best; formaldehyde gas cannot be relied upon for this purpose. Hydrocyanic acid, generated from potassium cyanide by the addition of sulphuric acid, is very efficient against bugs and all kinds of vermin, but is such a deadly gas that only experts should handle it.

FIG. 118.—Trunk locker for enlisted men.

SPITTOONS.—The sputum is frequently contaminated with the germs of tuberculosis, diphtheria, pneumonia and other diseases, generally without the knowledge of the man ejecting it; therefore it is a source of great danger and every precaution must be taken to prevent its dissemination in the air, especially in rooms occupied by a number of people. Spittoons or cuspidors should be provided in sufficient number, and punishment swiftly inflicted upon any one guilty of spitting on the floor. Cuspidors must be emptied and washed daily, preferably in boiling water, and then partly filled with a disinfecting solution. They must be so shaped as not to easily upset, while permitting easy cleaning. They should be set upon a square piece of linoleum, rubber matting or other washable material, so as to save the surrounding floor from possible pollution.

Hygiene of Floors.

In addition to the dust which settles upon them, the floors of barracks are constantly contaminated by mud and dirt brought from the outside, by sputum, fragments of food and various organic débris shaken from the clothing and bedding. All these impurities as they dry and become

ground into a fine dust by the tramping of shoes, are raised by air currents and made part of the atmosphere breathed by the occupants. Therefore to clean the floors, walls and furniture without raising and scattering the dust and contaminating the air is a vital hygienic desideratum. It is evident that the ordinary method of dry sweeping and dusting is inefficient and may be worse than useless since much of the dust, if not the whole of it, is simply scattered through the room to again settle over the same or other parts of it; meanwhile it pollutes the air and is much more dangerous than if it had been left undisturbed. *Floors should not be swept but cleaned with damp mops.* The process consists in dipping the mop in a bucket of water, wringing out, rubbing the floor, then washing and rinsing it in another bucket of water. Dust should be removed by catching it on damp cloths rubbed on the woodwork and furniture, especially all ledges, mouldings and shelving. The feather duster has become obsolete. The soldier's former way of cleaning floors by pouring streams of water upon them, preparatory to sweeping and scrubbing, is pernicious and should never be permitted. It fills the joints, fissures and holes with moisture, thus promoting the breeding of micro-organisms, besides causing the wood to warp, crack and decay. Scrubbing is the best method of cleaning mineral floors (tile, marble, terrazo, etc.); it may also be necessary for wooden floors when very much soiled, but it must be done with as little water as possible; in such case the better plan would be to detach and disintegrate muddy or incrusted spots with a wet stiff brush, previous to mopping the floor.

An excellent system, to prevent the raising of dust, consists in coating the floor with an agglutinative substance to which the dust adheres, but from which it is easily removed, once or twice a month, by a stiff broom or brush, in little rolls or particles too heavy to rise and float in the air. For this purpose various preparations in the market are well spoken of.*

In this connection may also be mentioned the vacuum cleaning system whereby all dust is completely removed by suction from carpets, hangings, upholstery and decorations without the least air pollution. Wood and tile floors are cleaned in the same manner, previous to mopping. An obvious advantage of this system is the pumping out and removal, together with the dust, of much of the musty and germ-laden air which too frequently stagnates in obscure corners and clings to upholstered furniture.

*Pulverifuge Encaustic of Coppin; the Dustless; Standard Floor Dressing, etc.

CHAPTER XXV.

MILITARY HOSPITALS.

The typical post hospital consists of a main or administration building, with a wing on one side or both sides of it according to the number of patients to be accommodated, the main building and wings consisting of basement, two stories and attic. In the main building are the various administrative services, while the wings are exclusively used for wards and their annexes. When, on account of an increased garrison, such hospital is no longer adequate, it is usually enlarged by an addition in rear of the administration building and parallel with it so that the central halls of both structures are in line and connected by a covered way. In this addition are transferred the kitchen and mess-room, as well as the isolation and prison wards, dormitories, etc. At all of our large posts a separate annex, entirely detached from the hospital building and supplied with all necessary disinfecting appliances, is erected for the treatment of infectious diseases. (See chapter on *Disinfection.*)

The administration building of the post hospital is mostly without verandas, but usually has a front porch over the main entrance, corresponding to a balcony on the second floor. The wings are provided with verandas on each floor and on both sides, the upper and lower verandas being connected by stairways.

In the administration building the arrangement is as follows: In the basement are the boiler room with water or steam heating apparatus, heater room to supply hot water throughout the building, fuel room, store-rooms, dead room, lavatory, etc. On the first floor (Fig. 119) is an ample vestibule, with dispensary and room for pharmacist on one side and, on the other side, offices for the surgeon and his assistant; further back are the kitchen, pantry and mess-room. On the second floor (Fig. 120) are the operating room, sterilizing room, instrument room, surgical ward, surgeon's toilet, laboratory, recreation room, linen room and n.-c. o. room. In the attic are the isolation ward with toilet, prison ward with toilet and dormitories for hospital corps men, also with toilet.

The wing is 73 feet 7 inches long, with both stories exactly alike. On entering it from the main building, there is a lavatory on one side and a bath-room on the other, each 11 feet 9 inches long. The rest of the wing,

on each floor, is occupied by the ward; this is 60 feet 9 inches long and 23 feet wide, inside measurement. It is lighted by 4 windows on each side and 2 at the end, and contains 16 beds in two rows, namely two beds between the windows and one near each corner. The heating is by the direct-indirect system, the hot water or steam radiators being placed

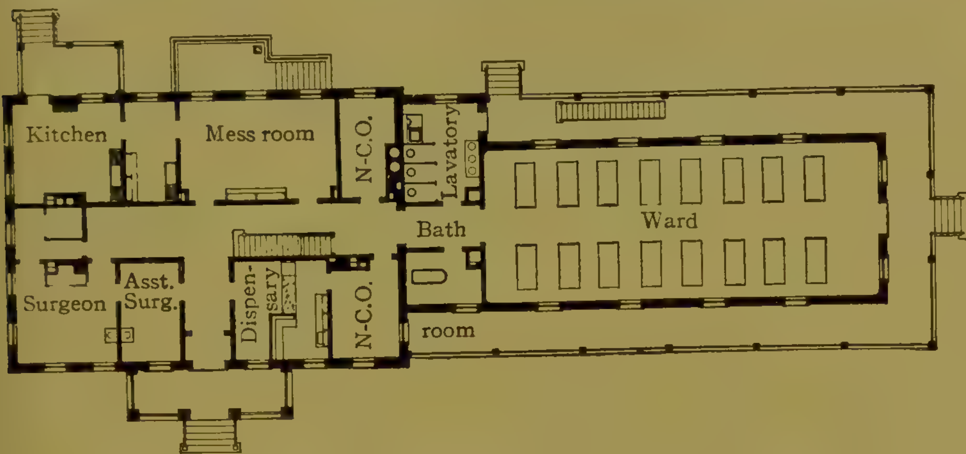


FIG. 119.—Standard post hospital for 36 beds. First floor.

under the windows. The ventilation is effected by two aspirating shafts, 20 x 22 inches, placed in the inner wall; two outlets (lower and upper) open in each shaft.

The general specifications governing the construction are mostly the

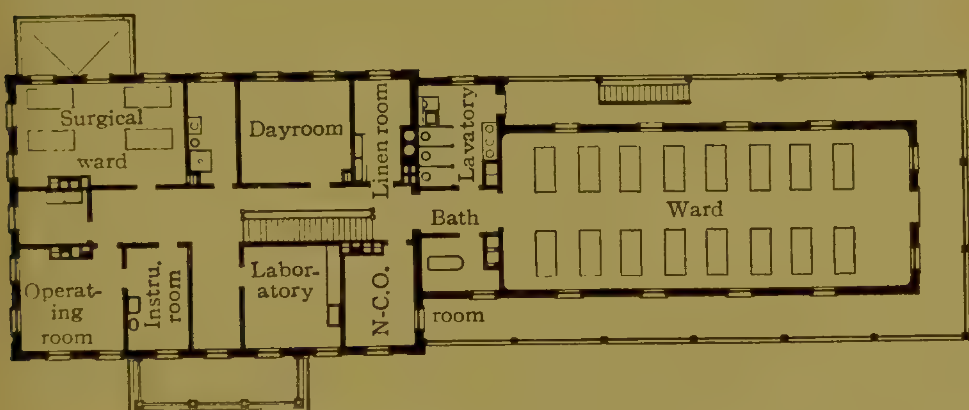


FIG. 120.—Standard post hospital for 36 beds. Second floor.

same as those already described for barracks. The entire structure, with exception of the concrete footings and stone foundations, is of brick. All exterior walls are built hollow, the "shells" being tied together with galvanized steel ties every sixth course. The walls and ceilings are lathed and plastered. The basement floor is of concrete; the floors of first and

second stories, except as noted below, are of wood, rarely of reinforced concrete finished with cement. The exterior walls in contact with earth,

FIG. 121.—Post hospital in the Tropics.

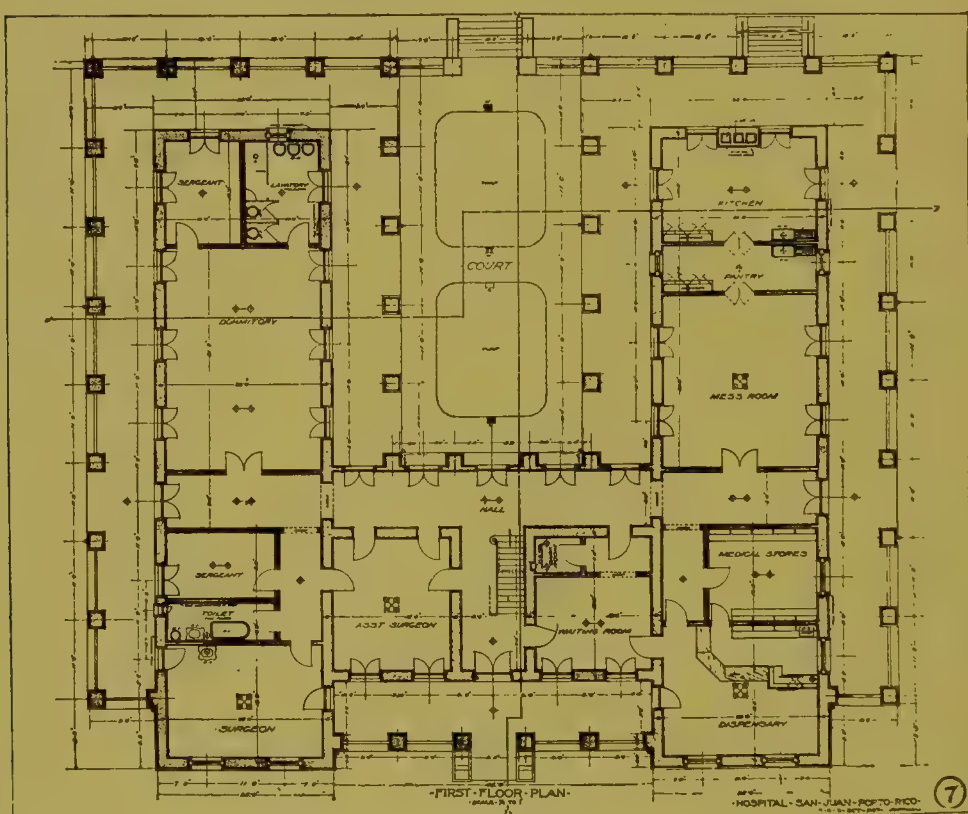


FIG. 122.—Post hospital in the Tropics. First floor plan.

from bottom of footings to the grade line, are given a heavy coat of boiling-hot asphaltum, or similar waterproofing compound, and plastered over with cement mortar. All interior walls receive a damp-proof course,

inches below the floor level, composed of two layers of waterproofing felt cemented with hot asphaltic cement, or of slates imbedded in cement.

The floors of all lavatories, toilet rooms, operating room and its annexes are of 2-inch hexagonal, vitreous, white tiles, with border of one row of 3 x 6 inches glazed white tiles. All rooms having tile floors are likewise tile wainscoted, 5 feet high in operating room and annexes, and 4 feet high in the other rooms, with 3 x 6 inches glazed white tiles having concave base and rounded top, curved angles at corners and rounded return at

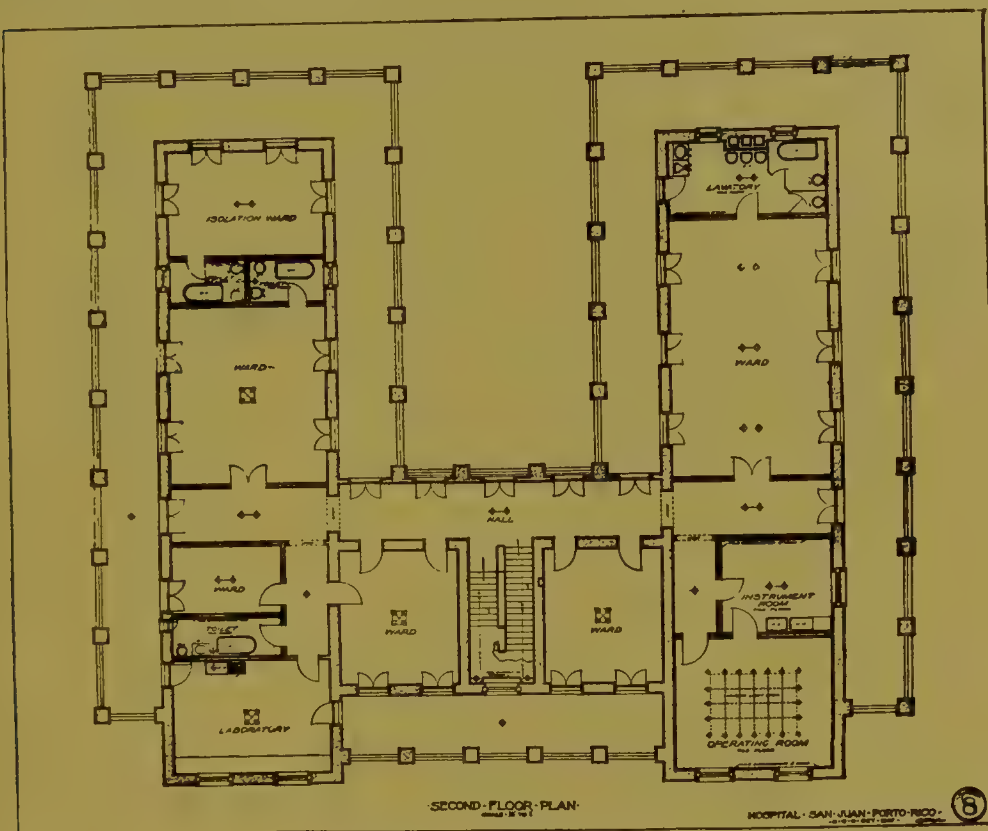


FIG. 123.—Post hospital in the Tropics. Second floor plan.

openings. In all lavatories, above basement, the partitions are usually of Italian marble around bath-tubs, water-closets, showers, urinals, etc., while all metal parts are of nickel-plated brass.

All finished wood floors and stair treads are given, by the contractor, two coats of floor polish, the last coat to be well rubbed down with flannel cloth or floor brush. This polish consists of paraffin dissolved in linseed oil, to which liquid drier and turpentine are added. To keep these floors in perfect condition, a suitable dressing must be applied and well rubbed in at least once a month. In our hospitals, this dressing consists of a

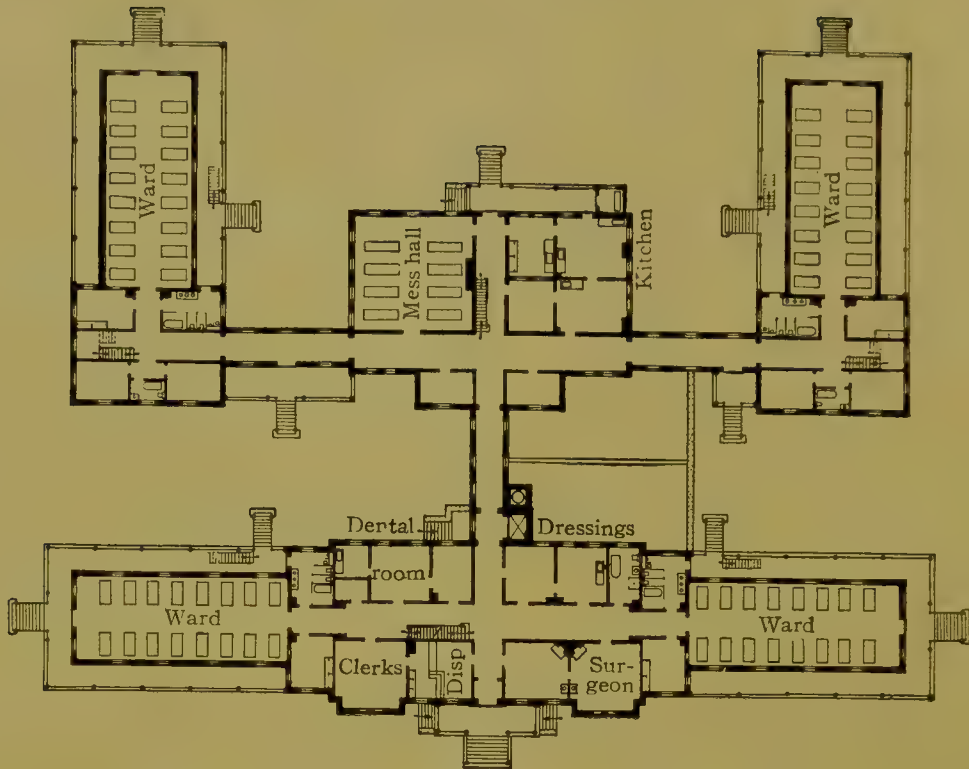


FIG. 124.—Brigade post hospital for 132 beds. First floor.

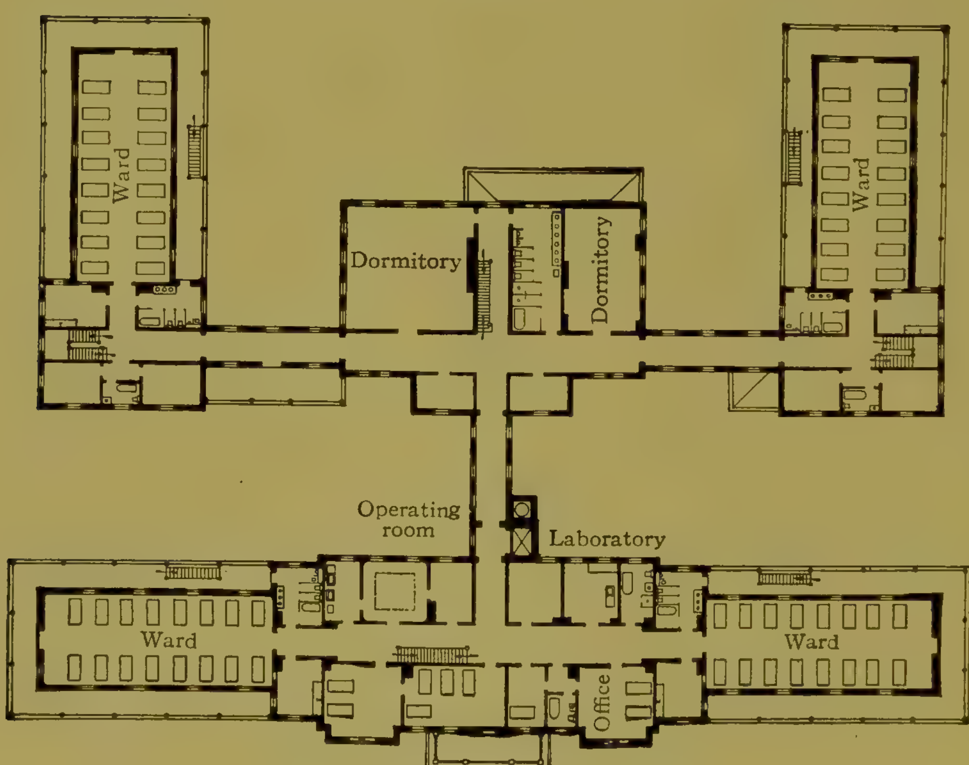


FIG. 125.—Brigade post hospital for 132 beds. Second floor.

solution of 1/2 pound of paraffin and 2 pounds of beeswax in 1 gallon of turpentine. Munson recommends one ounce each of paraffin and wax in a quart of turpentine.

In the tropics, where skilled labor is hard to procure and the woodwork often attacked by boring ants, it has been found advantageous to build hospitals and other public buildings of iron and concrete. The specifications for the construction of a military hospital at San Juan, Porto Rico,

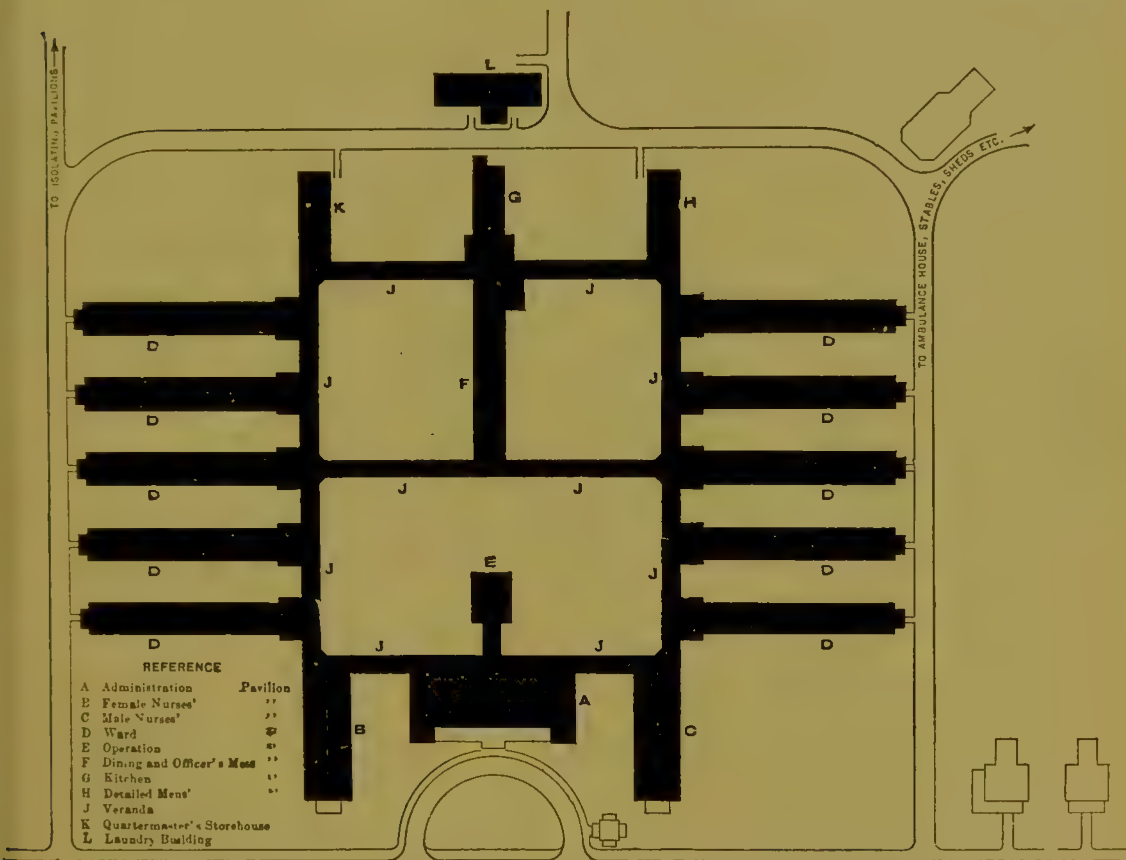


FIG. 126.—Plan of the U. S. Army general hospital, at the Presidio, San Francisco, Cal.

call for a 2-story reinforced concrete and cement structure, with high ceilings, wide porches and electric lighting (Figs. 121, 122, 123).

At large posts, the hospital assumes various shapes according to local conditions, or as the result of several successive extensions, but seldom departs materially from the above structural specifications (Figs. 124, 125).

General Hospitals.—The plans of large permanent hospitals, such as base or general hospitals, while remaining within the generally accepted principles of hygiene and administration, are susceptible of wide variation, according to the views of medical officers and architects, available

means and peculiarities of site. The pavilion system is the one that most commends itself, the pavilions being conveniently grouped and so connected with all the other buildings as to secure efficient administration. Each pavilion should be of 2 or 3 stories, with a ward and annexes on each floor, each ward to accommodate about 30 patients. One-story pavilions, in a permanent hospital, involve an unnecessary waste of space and material, and cause a very inconvenient scattering of wards. The general hospital at Presidio, San Francisco (Fig. 126), is excellently planned and one of the best types of that class, but open to the objection that its pavilions are 1-storied; the ward, excluding lavatory and service rooms, is 153 feet long and accommodates at least 40 patients, a larger number than should be placed in one room.

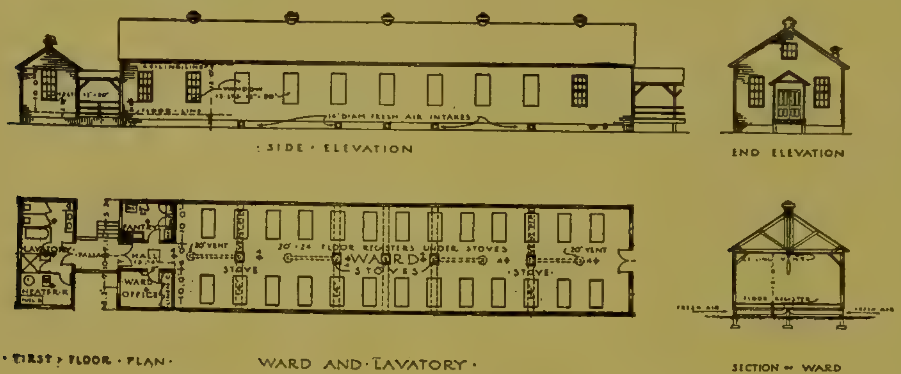


FIG. 127.—Elevation and floor plan of a pavilion.

Temporary General Hospital.—In the event of war, when preparations must be made quickly for large numbers of sick and wounded, the pavilion system necessarily imposes itself. The plans and specifications for temporary base and general hospitals, on this system, are on file in the Surgeon-General's Office so that they can quickly be put into execution.

The buildings are of simple construction and can be erected by ordinary builders with material that can be purchased in any market. In the interest of simplicity a single type has been adopted for all purposes, and the various buildings differ only in their interior arrangement. They are all 1-story substantial frame structures, with walls and ceilings finished with tongued and grooved, beaded boards, heated by stoves and roofed with corrugated iron. One-story pavilions are preferred because of the greater simplicity of construction, the greater facility of heating and ventilating and, in case of fire, the lesser risk to the patients.

Each ward (Fig. 127) consists of a building 120 feet long and 26 feet wide, with ceiling 12 feet high, lighted by 10 windows on each side. It is

connected, by a passage 10 feet long, with an annex in which are the lavatory on one side and the water heater on the other. In the end nearest the annex is a room on either side, one for special diet and the other for office and linen room. The ward proper is 106 feet 8 inches long and accom-

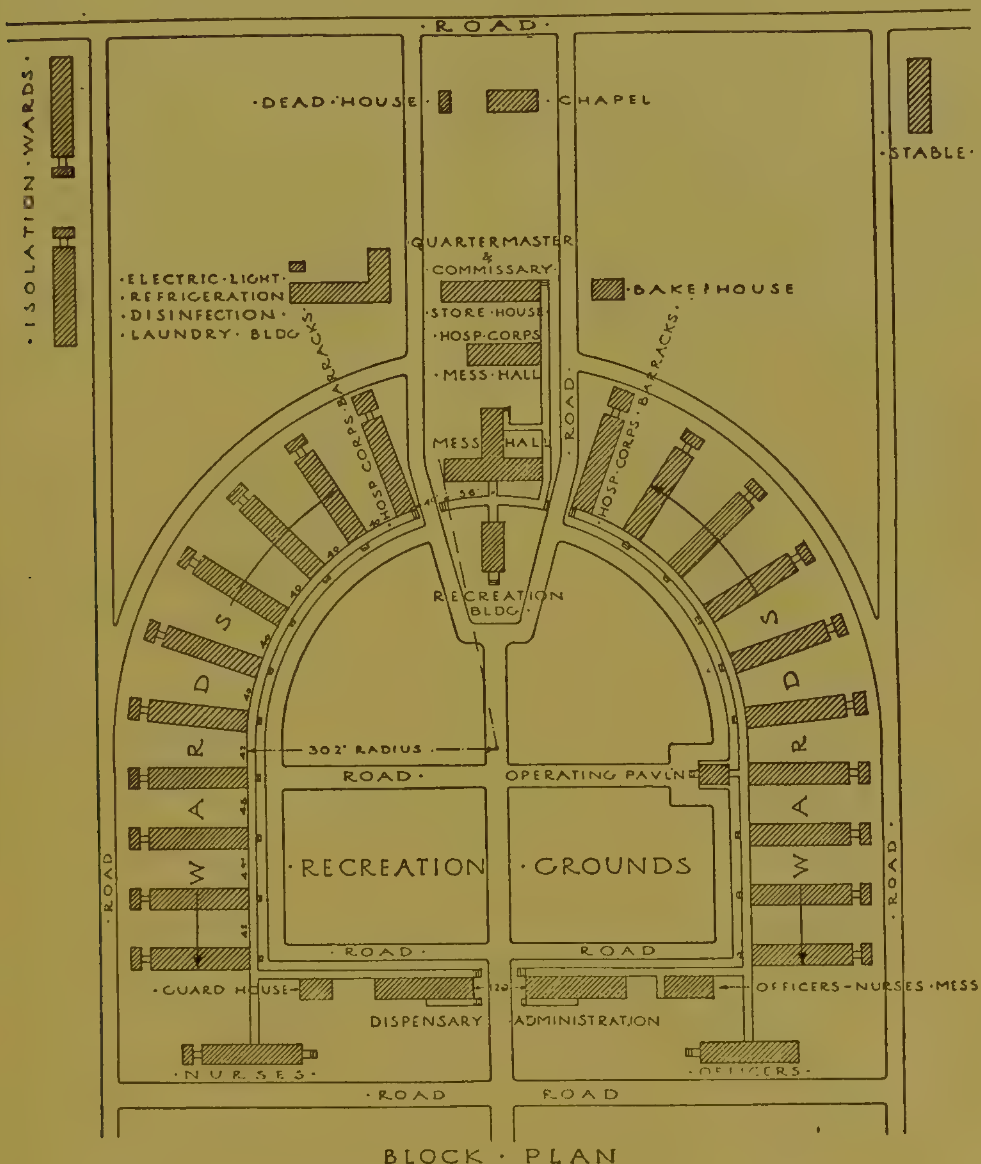


FIG. 128.—Plan for temporary base hospital, with pavilion wards.

modates 26 beds, each patient having 106 square feet of floor area and 1,272 feet of cubic space which, under the circumstances, is quite sufficient. It is heated by 5 jacketed stoves with bent pipes running up into ventilation shafts. The ventilation is effected by means of galvanized pipes

conducting fresh air under the floor to the stoves, and of 5 ventilation shafts which receive the smoke pipes and are topped with star ventilators.

The general arrangement and grouping of the pavilions varies greatly. The wards may be set, like divergent rays, on the outer side of a covered way shaped like a horseshoe (Fig. 128) or an inverted letter V, with all or most of the other buildings inside; they may also be located on each side of a covered way, or on two sides of a square or rectangle. The chief objects to be attained, in determining this general plan, are to give each ward a maximum of space, light and sunshine, secure accessibility to all parts and convenience of service, and provide open, attractive grounds for the use of convalescents.

CHAPTER XXVI.

AIR.

Composition.—Air is a mixture of several gases, chiefly oxygen, nitrogen and argon, in the proportion, by volume, of about 21, 78.15 and 0.85 respectively. The other normal constituents of air, all in very small or minute quantities, are carbon dioxid, ozone, aqueous vapor, ammonia, nitrous and nitric acids, and dust. The proportion of all these constituents varies only within narrow limits, and when temporarily disturbed becomes again quickly readjusted under the operation of natural laws.

Oxygen is indispensable to the maintenance of all life, animal and vegetable. Without it there can be no growth or repair of tissues, nor combustion and destruction of organic and inorganic matter. In man and animals, the oxygen of the air is absorbed in the lungs by the red blood-corpuscles, uniting with the hemoglobin, or coloring matter, and carried by the arterial current to all parts of the body; it is taken up by the tissue cells, where it combines with the metabolized carbon and hydrogen, the resulting carbon dioxid and water being conveyed by the veinous blood to the lungs and eliminated. According to Prof. Foster, an average adult inhales a little more than 7 pounds of oxygen daily, about one-fourth of which, or nearly 2 pounds, is absorbed by the lungs.

Plants breathe like animals by absorbing oxygen and giving off carbon dioxid, a function especially active during germination and blossoming; oxygen is therefore essential to their growth and life.

Nitrogen is an inert gas, chiefly serving to dilute the oxygen; it takes no part in the respiration of animals but contributes to the nutrition of plants. It is the most important constituent of animal tissues. Animals obtain it exclusively from the vegetable world, while plants derive it from the soil and the air; from the soil out of nitrates and salts of ammonia, and from the air through the agency of certain bacteria. These bacteria develop nodules, ranging in size from a pin's head to a small pea, upon the roots of many plants, particularly species of the leguminous family (peas, beans, clovers) which, in consequence, often thrive in poor soil and enrich it. It is worth noticing that nitrogen is also one of the principal ingredients of explosive powders, so that if it is indispensable to the life of animals it is also one of the chief agents in destroying it.

Argon, so far as known, is an inert, indifferent gas.

Carbon dioxid or carbonic acid (CO_2) is a constant constituent of air, averaging from 3 to 4 parts in 10,000, or 0.03 to 0.04 per cent. It is derived from the respiration of animals, the combustion of all substances used for heating or illuminating purposes, the oxidation, fermentation and decomposition of all organic matters, the eruption of volcanoes, etc. The ground-air is much richer in carbon dioxid than the open air above, sometimes reaching 100 or more parts in 10,000; by diffusion it contaminates the layers next to the ground which on this account contain much more of CO_2 than the normal average.

An adult man exhales about 15 cubic feet, or about 2 pounds of CO_2 a day Illuminating gas gives off twice its volume of it. One ton of coal, by its combustion, produces three tons of CO_2. The burning of coal, therefore, is the chief source of carbon dioxid in the atmosphere, the yearly production of this gas being estimated at 1200 millions of tons. But this has no appreciable effect upon the respiration of animals. Thus, although the atmosphere of London is daily tainted with 90,000 tons of CO_2 and 300 tons of soot, that great metropolis has the lowest mortality of any of the large cities of Europe.

How is this great excess of CO_2 in the atmosphere disposed of and the normal ratio of 0.03 per cent. maintained? Much of it is absorbed by the ocean, since water takes up its own volume of the gas, but a larger proportion is removed by plants which, through the action of their green pigment, or chlorophyl, and under the influence of light, decompose it, retaining the carbon and discharging the oxygen. Thus it is estimated that one acre of woodland withdraws, in one season, 4 1/2 tons of CO_2 from the air, appropriating 1 1/4 tons of carbon and discharging 3 1/4 tons of oxygen. This function of plants, carried on through their foliage, is a purely nutritive one and not concerned in their respiration, the oxygen thus returned to the air far exceeding the comparatively small amount absorbed in the performance of the latter function, and maintaining the normal equilibrium of atmospheric gases. Since the decomposition of carbon dioxid by plants ceases in darkness, while their respiration continues, an increase of that gas may be expected at night in rooms in which plants are kept, especially when blossoming, if not properly ventilated.

Ozone, an allotropic form of oxygen, is a normal but not constant constituent of the air, being only found in the country and at sea, and the amount increasing with the altitude. It has very strong oxidizing properties, eagerly combining with decaying animal or vegetable matter so that it

quickly disappears wherever such matter is abundant. Any locality, therefore, where ozone is present may be assumed to be free from putrefying organic substances. Very little is known of the effects of ozone on the system beyond the fact that, except in largely diluted form, it is dangerously irritating.

Ammonia, as well as nitrous and nitric acids, are always present, at least in traces in the air, and benefit the soil through the rain which dissolves more or less of them.

Aqueous vapor is a constant and very important constituent of air, although variable in amount and unequally diffused. It is derived from many sources: the evaporation of water and soil, the evaporation from the skin and lungs of animals, from combustion and from the transpiration of plants. An adult man, under average conditions, gives off from 3 to 4 pounds of watery vapor from his skin and lungs, namely 2 1/2 pounds from the skin and the remainder from the lungs. The amount given off by animals, however, is very small compared to that contributed by plants which absorb water in large quantity from the soil, through their roots, and exhale it as vapor through the pores (stomata) of their leaves. According to Hellriegel, the amount of water thus exhaled by plants is from 250 to 400 times the weight of the dry wood formed during the same time.

The amount of invisible vapor which the air can hold depends on the temperature; thus the amount which at 70° F. would condense into cloud, fog or rain, will completely disappear at 90° and leave the sky perfectly clear. The degree of temperature to which the air must be cooled to cause condensation of its vapor is the "dew point," while the air which is so charged with vapor that any lowering of temperature would produce precipitation is said to be "saturated." When the air is saturated, it is unable to absorb more vapor and therefore evaporation from the skin ceases, but perspiration being a necessary function of life continues, although very much diminished; this is a very uncomfortable weather condition popularly described as "sticky" in summer and "raw" in winter.

Relative Humidity.—The "relative humidity" of the air is the percentage of the total amount it can take up to become saturated at any given temperature. Thus the relative humidity of the Eastern States ranges from 60 to 75 and diminishes as we advance into the drier interior States, reaching its minimum in Arizona where it averages only 43. The temperature we actually experience, that is, our subjective sensation of heat and cold, is chiefly determined by the amount of our perspiration and consequent evaporation, and this depends upon the dryness of the air

more than its temperature, or, in other words, upon its relative humidity. The drier the air the more freely we perspire and the more active is the evaporation of the sweat and cooling of the skin. Our skin surface, always excreting sweat, may be compared to a wet bulb thermometer, so that the reading of the latter is an index to our sensation of heat. Thus, while the mean July reading of the wet bulb thermometer in Boston is 65° F., and 75° in Savannah, it may be only 60° at Yuma, Arizona, in spite of its much higher, torrid summer heat; Arizona, therefore, is cooler and more comfortable in hot weather than the Eastern States, provided one is protected from the direct sun-rays. Dryness of the air is also expressed by the difference between the wet and dry bulb thermometers; this difference is about 5° F. in the Eastern and Southern States, increases in the interior and reaches its maximum of about 20° in Arizona. There the skin is dry and harsh, the hair crisp, the furniture shrinks and falls apart, newspapers are brittle and pencils make no marks.

It has been seen that humidity, by checking perspiration, renders hot weather more unbearable; but moist air is also a better conductor of heat, so that the body, in cold weather, parts more rapidly with its temperature in damp than in dry air. It follows, therefore, that humidity produces opposite effects, intensifying both heat and cold, and that dry air is preferable in either extreme of temperature.

High humidity, in a cold or temperate climate, increases the urine and intestinal secretions, causing great dilution of the blood, slower circulation and other conditions tending to develop the phlegmatic temperament. Dry air, on the contrary, decreases the liquids of the body, quickens the pulse and stimulates the nervous system, producing a more restless and excitable temperament.

Ocean and Lakes.—The influence of large bodies of water on the temperature of the air and climate is also worth noticing. Water having much greater specific heat than land is much more slowly heated by solar radiation, but the heat penetrates deeper and is not so easily parted with. It follows that the diurnal and annual changes are much smaller on the ocean or near the coast than in the interior; the range of temperature is smaller, the winter milder, the summer cooler, and the climate therefore more equable. This influence is also exerted by great lakes; thus a difference of 10 to 15° F. has been noticed between the northern and southern shores of Lake Ontario in winter, the southern shore being protected by the water against the northern wind.

Forests.—The influence of forests upon the climate is only local and not marked. They mitigate extremes of temperature, the summer heat much

more than the winter cold, and check the violence of the winds. Their cooling effect in summer is due to the shading of the ground, the increased surface of heat radiation, the active radiating power of leaves and the free evaporation of the moisture which they discharge. There is no proof that the air of forests is richer in oxygen or ozone than outside air, but it is often stimulating from the exhaled essential oils it contains.

Effect of Altitude.—As we rise above sea-level, air pressure diminishes; at an altitude of 6,000 or 7,000 feet it has decreased one-fourth and the first symptoms of "mountain sickness" may be noticed. As we rise still higher, these symptoms become aggravated; they consist in weakness, headache, dizziness, nausea, increased pulse, palpitations, quick irregular respiration, nose-bleed and fainting spells. Mountain sickness is due to diminished air pressure which affects the system in two ways: 1, by the dilatation and congestion of the pulmonary blood-vessels, causing a reduction of breathing surface and embarrassing the action of the heart with tendency to dilatation of the right ventricle; 2, by the failure of the red blood-corpuscles to carry enough oxygen to the tissues, so that the organs are unable to do their work, the heart and brain being especially sensitive to this deprivation.

If the change of altitude is not too great, too sudden, or of too long duration, the symptoms are slight and ephemeral, lungs and heart soon recovering their normal condition. But if the change is permanent, some time is required for the system to accommodate itself to it. Thus people going from the Eastern States to reside at Cheyenne, Wyo., or the neighboring post of Fort Russell, about 6,000 feet high, may not be aware of any difference in their sensations, but it will be several weeks before they regain their full capacity for active physical and mental work. There is always danger for people with unsound heart and lungs to ascend to the summit of high mountains by steam or electric cars, their power of accommodation being unequal to the great and sudden fall of air pressure.

It has been observed that in people going to reside at high altitudes, there is at first a decrease of their red blood-corpuscles, but that, after a few days, the number of corpuscles increases and soon exceeds the original count. This, and an enlarged lung capacity, are nature's adjustments for life in a rarefied atmosphere, which render possible the growth and prosperity of cities like Mexico at 7,524 feet, Quito at 9,520 and Leadville (Colo.) at 10,200 feet above sea-level.

As we approach an altitude of 16,000 feet, the temperature in the shade becomes that of an arctic climate, while the sun-rays blaze down more fiercely than at sea-level where they are tempered by denser air and watery

vapor. Giles* observed that at an altitude of 16,500 feet, while the temperature at noon, in May, stood at —20° F., the sun thermometer registered 165°; one side of the hand turned to the sun would be scorched while the other was chilled, as if in contact with cold water. In the opinion of that author, it would have been sufficient to remove one's hat a few moments to incur the risk of sunstroke.

ATMOSPHERIC DUST.—Dust is a normal and very important constituent of the air, being derived from the soil by the action of the winds, from combustion, volcanoes and meteorites, while, at sea, much salt dust is shaken off from the spray of the waves. It is of organic and inorganic origin, a certain proportion of it consisting of micro-organisms which are either free or, more commonly, adherent to mineral particles. Dust is abundant everywhere but especially in the vicinity of towns and manufacturing centers. Smoke consists chiefly of fine carbon dust; it has been estimated that a puff from the cigarette smoker contains 4,000,000,000 of it. The haze of summer days is chiefly the result of smoke. Much of the atmospheric dust is readily visible to the naked eye, but more is microscopic and even ultra-microscopic, that is to say, so extremely tenuous as to be beyond the power of the microscope.

The chief function of atmospheric dust is to condense aqueous vapor and cause precipitation, each particle being a nucleus upon which a minute droplet forms, these droplets coalescing into drops. Were it not for this dust, there would be no cloud, no mist and no rain, the aqueous vapor condensing directly upon the surface of the earth, inside and outside of houses, wherever the air penetrates.

Mineral dust is of little hygienic importance except when so abundant as to affect the respiratory passages or conjunctivas. Of more interest are the micro-organisms always mixed with it. This so-called microbial dust varies greatly in quantity, being always more common inside houses than in the open air. In a bed-room, Miguel found 4,500 to the cubic meter, and 40,000 in the ward of a hospital; in a barrack, at reveille, Kiener and Aldiber counted 220,000. The number found in any room varies enormously according to the occupation of the inmates, the agitation of the air and the currents formed through it; for dust settles rapidly on walls, woodwork and furniture in a quiet atmosphere, but is again quickly raised and floated by air disturbances.

Micro-organisms are much more abundant in towns than in the country, in the proportion of nearly 10 to 1; thus while the average number in Paris is 3,910 to the cubic meter, that at Montsouris (just outside the city) is only

*Climate and Health in hot countries.

455 (Miguel). The number decreases with the altitude and they soon disappear above 6,000 feet. Sea air, 100 miles from the coast, is also entirely free from them, as well as the high altitudes of the Arctic Circle.

The rôle of these desiccated micro-organisms inhaled or swallowed with the atmospheric dust, in propagating disease, is not clearly established. It is evident that only a few have any pathogenic significance and that they are rarely found in such number and under such conditions as to be a serious menace. It must be admitted, however, that the danger exists, especially from the germs of diphtheria, tuberculosis and pneumonia, although generally remote and often negligible.

CHAPTER XXVII.

VENTILATION.

"*There is nothing so priceless and yet so costless as air. There is no financial investment which does or can yield so sure and so large returns as money wisely expended for pure air.*" (Prof. S. H. Woodbridge).

Ventilation may be defined as the continuous and systematic renewal of air, so as to keep it as fresh and pure as possible.

Causes of Air Contamination.—The air of inhabited buildings is fouled by many causes, but especially by respiration, excretions, combustion and decomposition.

In the process of respiration, a certain amount of oxygen is absorbed by the blood, so that expired air contains only 16.40 parts of this gas; the proportion of nitrogen remains unchanged, whereas carbon dioxid is increased from 0.03 to 4.40 per cent., the lungs of the average adult at rest eliminating about 16 cubic feet of it in the twenty-four hours, or 0.66 of a cubic foot per hour. Expired air has nearly the temperature of the body and is therefore generally lighter than outside air; it is, furthermore, saturated with moisture, the amount given off per man in a day being about a pound. Whether expired air contains any special organic matter, some volatile alkaloid, as described by Brown-Séquard, seems quite doubtful, the weight of evidence being against such assumption. "In ordinary quiet respiration, no bacteria, epithelial scales, or particles of dead tissue are contained in the expired air. The cause of unpleasant, musty odors in rooms may in part be due to volatile products of decomposition from decayed teeth, foul mouths, or disorders of the digestive apparatus, and in part to volatile fatty acids given off with or produced from the excretion of the skin, and from clothing soiled with such excretions" (Drs. Mitchell, Billings and Bergey). Many germs, however, may be contained in the particles of saliva or mucous secretions ejected in coughing, sneezing or even speaking, sometimes of a dangerous character, as in diseased conditions of the throat, tonsils or lungs.

The skin contributes materially to air pollution. It excretes two or three times more water than the lungs; this water, or sweat, contains fatty acids, ammonia and soda salts; mixed with the sebaceous secretion,

epidermic débris and dust, it soon gives rise to ill-smelling products. The CO_2 excreted by the skin is a negligible quantity.

From these several sources are derived the offensive organic and nitrogenous matters, either gaseous or in the form of invisible dust, which contaminate crowded rooms, being slowly oxidized and long retained by hygroscopic surfaces and clothing.

Combustion, like respiration, absorbs oxygen and gives off CO_2 and aqueous vapor. Besides raising the temperature of the room, it also generates various gases and volatile substances according to the fuel or illuminant used, namely: carbon monoxid, nitrous and nitric acids, compounds of ammonia and of sulphur, marsh gas and fatty acids. An ordinary burner consumes 5 cubic feet of gas per hour; as each foot of gas needs 5.33 cubic feet of air for its combustion, the burner will therefore require 26 feet per hour or 624 per day. Each cubic foot of gas produces, in burning, half a cubic foot of CO_2, therefore the burner, in one hour, will evolve 2 1/2 feet, or about 4 times as much as an adult man. Each pound of coal requires 300 cubic feet of air for its combustion, but most of the products pass up the chimney and do not contaminate the breathed air.

When many people are crowded in a badly ventilated room, the sense of smell first takes cognizance of the fouling of the air, which becomes close and musty. Then certain symptoms manifest themselves; first, discomfort and oppression, followed by headache, fall of temperature, perspiration, exhaustion, and, in extreme cases, delirium and death. These symptoms are partly due to overheating, the products of respiration and combustion, moisture, fetid odors, etc., but especially to lack of oxgyen. When death occurs, as in the historic instances of the Black Hole of Calcutta, the prisoners of Austerlitz, the passengers on the steamer Londonderry, etc., it is chiefly the result of asphyxia, that is to say, the deprivation of oxygen. Carbon dioxid has no special toxicity, and a ratio of 1 per cent. or even more, in otherwise pure air, can be borne for several hours without much inconvenience. But, after a while, should it continue to increase, the tension of the air becomes such that its excretion from the blood is much interfered with; thus is its accumulation in the system increased and asphyxia hastened.

Carbon dioxid being a necessary product of respiration and combustion, and its presence and amount easily ascertained, has been chosen as the index of air pollution, it being assumed that the proportion of other contaminating matters rise and fall with it, an assumption, of course, only approximately correct. The value and significance of such an index vary according to the source of the CO_2. If it comes chiefly from respira-

tion, it will indicate the proportion of accompanying excretory substances and micro-organisms, but if mainly from combustion, it will rather indicate the ratio of toxic gases. As thus understood, the permissible amount of CO_2 in air, that is to say, the amount which, with the corresponding accompaniment of deleterious substances, has no appreciable effect upon health, is 6 or 7 parts per 10,000, or an increase of 3 or 4 parts over the normal quantity. Such amount is not detectible by smell. Air containing 10 parts begins to be "close;" with 15 to 20 parts it is "stagnant," while with more than 25 parts it becomes distinctly musty and oppressive. There are few schools, factories, barracks, etc., in which the amount of CO_2 does not reach 10 to 15 parts. In crowded halls and theatres it may range from 50 to 75 parts, and, if only for a few hours, without any harm. In the cars of trains it often amounts to 20 or 25 parts, the air of smoking cars being particularly foul, frequently containing 4 to 5 times as much ammonia as the outside air and a notable amount of carbon monoxid. It is prolonged exposure to impure air, rather than the degree of impurity, which is detrimental to health; thus a constant ratio of 12 to 15 parts in bed-rooms, school-rooms or shops will impoverish the blood and impair the power of resistance to disease much more certainly than occasional exposures to air containing 40 or 50 parts.

Test for Carbon Dioxid.—The simplest test for CO_2 giving sufficiently accurate results for practical purposes is that of A. Wolpert, as modified by Prof. Boom. "Make a mark on any test-tube, say one inch from the bottom. Fix the bulb of an atomizer to a small glass capillary tube, sufficiently long to reach to the bottom of the test-tube, and in such a manner that a definite quantity of air is forced from the bulb through the tube at each compression. To use: Fill the test-tube exactly to the mark with a saturated solution of lime-water, take the apparatus into the outdoor air and find out how many compressions of the bulb are needed, driving the air slowly through the lime-water each time, to make the lime-water just turbid enough to obscure a pencil-mark on white paper placed beneath the test-tube and viewed from above" (*Hygiene and Sanitation, Egbert*). Repeat this operation in the room to be tested and note the number of compressions required. Assuming that the outdoor air contains the normal amount of CO_2, namely, 0.03 per cent., the amount contained in the air of the room will be to this normal amount as the number of compressions in the outdoor air is to the number in the room; for instance, if the air of the room requires only one-third the number of compressions needed in the outside air, the amount of CO_2 will be three times greater, or 0.09 per cent.

Carbon Monoxid (CO).—By far the most toxic of the gases liable to contaminate the air of inhabited rooms is carbon monoxid, the more dangerous from being odorless. It is chiefly derived from the leakage of illuminating gas and from imperfect combustion. Gas prepared from bituminous coal contains only 6 to 7 parts of CO, while water gas, now largely superseding it, contains about 30 parts and is therefore much more poisonous. It is also freely evolved from burning charcoal, a fact taken advantage of in some countries to commit painless suicide. The smoke of tobacco contains a rather large proportion of CO, two puffs of it upon blood being sufficient to demonstrate the absorption of the gas, by the spectroscope. The leakage of coal gas into the ground is enormous, amounting to at least one-fifth of the total output, and much of it may be aspirated into houses by the higher temperature of indoor air. Less than 1 per cent. of carbon monoxid in the air of inhabited rooms may cause the death of their occupants, owing to its great affinity for the hemoglobin of the blood which thus loses its property of carrying oxygen to the tissues and eliminating carbon dioxid. The usual qualitative test for CO is to expose water containing a few drops of fresh normal blood to the suspected air, adding a few drops of ammonium sulphide, and then examine the mixture with the spectroscope; its presence is revealed by the characteristic two bands of oxyhemoglobin.

Coal gas combustion also evolves sulphurous and sulphuric acids, some times enough to produce an unpleasantly irritating and acrid smell.

Air Purification.—The means employed by nature for the purification of air are winds and storms, oxidation, bacterial action, rain and vegetation.

The winds keep the constituents of the air in constant agitation, mixing them thoroughly and maintaining them in their normal relative proportions; they disperse noxious gases and organisms and subject them more completely to the destructive action of sunlight and oxygen. By oxidation, all organic matters are decomposed and transformed into simpler innocuous elements; these changes are materially assisted by the agency of bacteria. Rain washes out the air and carries its impurities into the soil. Vegetation, as already seen, removes the excess of carbon dioxid from the air and absorbs from the soil much moisture and organic matter.

Nature of Ventilation.—Ventilation is not an occasional or intermittent renewal of air; it is a continuous process, as is the pollution; it therefore implies a constant movement of air in two directions, inward and outward, the entrance of fresh air and the escape of foul air. The fresh air, however, does not drive out the foul air; it diffuses itself into the

room and dilutes the air already used so as to render it innocuous. Perfect ventilation would be that in which foul air is at once removed and replaced by pure outside air, so that none of the occupants of a room would breathe the same air twice; but this is not practicable; the incoming air cannot be kept separate from the air already used, but rapidly diffuses with it. A certain proportion of air will be inhaled more than once, and all that can be done is to so dilute it with fresh air that it will be harmless. The movement of air in ventilation should be imperceptible and never amount to a draft; that is to say, it must not usually exceed 3 feet a second. Cold and damp air is much more readily felt and likely to produce unpleasant currents than if at a temperature of about 50 or 55°; therefore it is advisable, in cold weather, to warm it moderately, thus combining ventilation and heating Much heating of the incoming air, however, is highly objectionable as it robs it of some of its purifying and invigorating properties.

Amount of Air Necessary.—One of the chief practical points in ventilation is to determine the amount of fresh air necessary to keep the carbon dioxid down to the permissible limit of 6 parts per 10,000, namely 3 parts as normal constituent of the air and 3 parts as the result of contamination. The amount discharged per hour by an adult male, during repose, but while awake, is 0.72 of a cubic foot, 0.60 by an adult female and 0.40 by children, with an average of 0.60 for a mixed community. The question is how much fresh air is required to dilute 0.60 cubic feet of CO_2 so that there will be no more than 3 parts of it (the permissible ratio of contamination) in 10,000 parts of air. It reduces itself to a simple rule of three:—

$0.60 : x :: 3 : 10{,}000$; hence $\frac{10{,}000 \times .60}{3} = 2{,}000$ feet. In the case of adult males, such as soldiers, the answer would be $\frac{10{,}000 \times 0.72}{3} = 2{,}400$. But, during sleep, adult males discharge only 0.56 foot, requiring about 1,900 feet of air for its proper dilution.

It thus appears that each person should receive, per hour, about 2,000 cubic feet of fresh air, in a steady, even, continuous manner, without draft or perceptible change of temperature. The larger the room the fewer renewals of air will be required in the same space of time and the slower the interior air movement; in other words, the larger the cubic space allowed to each occupant the more easily can the necessary amount of fresh air be furnished without draft. Experience shows that when the amount of air, per hour, introduced into a room, is more than three times its cubic capacity, a current becomes perceptible. It follows, then, that

the capacity of said room, or cubic space allowed to each man, should be at least $\frac{2000}{3} = 666$ cubic feet.

The floor space allowed each soldier in barracks varies too frequently in accordance with the strength of companies and the area of available quarters. All medical officers agree that it should never be less than 10 by 6 feet, or 60 square feet; with a ceiling 12 feet high the soldier will thus have a minimum cubic space of 720 feet. It is highly desirable, however, to make the minimum floor area 80 square feet and the cubic space 960 feet. The workable basis upon which to determine the size of dormitories should be a space of 1,000 cubic feet per man.

In hospitals, to prevent the spread of disease, not only is thorough ventilation necessary, but as much room as possible should be provided so that the patients may be properly separated. The cubic space allowed each patient in wards should never be less than 1,600 feet and should reach 2000 feet whenever practicable.

The ceiling of barracks, in cold and temperate climates, must never be less than 10 nor more than 12 feet high. If higher than this, the upper part of the room is difficult to aërate and to clean; the added space is of but little use for ventilation; much heat is lost, and the cost of construction is much increased without corresponding gain. This, however, does not apply to hospitals, schools, or public halls, etc., in which special means of ventilation are provided. In the tropics, also, where artificial heat is not necessary and an active air movement is desirable, high ceilings, together with high doors and windows, are advantageous.

NATURAL VENTILATION.

Ventilation is conveniently described as natural and artificial, but both systems are often more or less combined.

Natural ventilation is the effect of two forces: perflation or the blowing of the wind, and the difference of density between the outside and inside air. They are both constant but quite variable in degree. The movement of the air may be a hardly perceptible breeze or the blast of a storm, but is seldom if ever entirely absent, often having a velocity of 2 or 3 feet a second in apparently perfectly still atmosphere and being seldom less than 5 or 6 feet. Free perflation, through doors, windows and ventilators, affords the best kind of ventilation and should be used whenever possible, even if only for a few moments every day. In barracks or other buildings with many occupants, the windows should be opposite each other so that the air may be swept through the room. Air thus naturally

blown in possesses a freshness and produces a stimulating and purifying effect not equalled in any system of artificial ventilation.

The difference of density between the outside atmosphere and the inside air results from their unequal temperatures, namely from the heating of the buildings; heating is therefore more or less involved in ventilation and one of its necessary factors. As air gets warmer it becomes lighter and tends to rise and escape through the openings in the upper part of the room or the ventilating shafts; to fill the vacuum thus made, the colder air pours in from the outside through the lower openings. If a vertical slit be cut in the wall of a room, or one of the lateral sashes of a French window opened, it will be noticed that the direction of the current through the lower part of the opening is inward while that through the upper part is outward. Between the two currents is a neutral zone where the air is not displaced. The further above this zone is an opening made, the greater will be the difference of density and the more active the outward current of air through it. It follows that, for the proper ventilation of a room, at least two openings are needed, preferably at different levels, one for the incoming and the other for the outgoing air. With only one opening, unless it be reasonably large, the two currents will oppose each other with much friction and loss of efficiency. Thus, if a lighted candle be placed in an open 2-quart bottle, it will speedily die out, whereas if the stopper be pierced with two holes and glass tubes of unequal length placed in them, although their combined areas are less than the area of the open mouth, the candle will continue to burn, the inward and outward currents passing through the separate tubes without interference (Fig. 129).

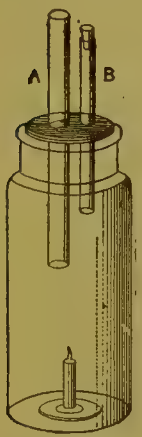


FIG. 129.—Showing the necessity of two currents to sustain combustion (*Munson.*)

In an inhabited room, the air in contact with the bodies of the occupants becomes warmer; it mixes with the expired air which has a temperature of about 97° F. and together rise in slow but steady waves toward the ceiling. Although expired air contains a large proportion of CO_2, it is so rarefied that it weighs only 1.12 grams per liter, whereas ordinary air at 62° weighs 1.22 grams. It is a law that, within a limited space, gases which have no chemical action upon one another are uniformly diffused, independently of their respective density. The CO_2, therefore, although heavier than air, remains diffused mostly in the upper layers of the air and, with good ventilation, should escape before it can vitiate the lower layers. This ascentional movement of air which has been used and polluted, is nature's way to remove it as soon and as completely as possible. The incoming

fresh air which replaces it should follow the same upward direction. Therefore, air inlets, in natural ventilation, are near the floor, or at least lower than the outlets, and the outlets near the ceiling. Downward currents are prevented by insuring a sufficient velocity to the streams of vitiated air escaping into the atmosphere and by protecting the tops of ventilating shafts from the perturbating action of winds.

Air enters a house not only through the openings especially provided, but also through all joints and interstices, and even through the walls. This filtering in of air, however, as shown by Recknagel, is too small to be of any value as a ventilating factor, although often sufficient for the production of unpleasant cold drafts. Good sanitary construction requires that a house should be as impermeable to air as possible.

For the admission of fresh air, inlets through the walls are used; they will be further considered under artificial ventilation. Various devices are also resorted to. The simplest and commonest is to open the lower and upper sashes of a window, or either of them. To prevent draft the lower sash may be raised and a board fitted in the opening; then the air inlet is at the broken junction of the two sashes. Another device, more expensive, consists in setting a glass plate vertically on the window sill, a couple of inches inside the lower sash, so that when the latter is raised, the stream of air, striking the plate, is diverted upward.

A method of natural ventilation now coming into pretty general use is the insertion of ventilating panels in windows, below and above, the sashes being raised or lowered for the purpose. The lower panel contains one or two boxed inlets through which the admission of air is regulated by a valve and the air itself filtered and diffused upward; the upper panel contains the outlets (Fig. 130). This method is specially valuable in winter. French windows are frequently constructed with a transom above, hinged outward for the escape of air, thus permitting a certain degree of ventilation without opening the sashes. The outlets may also be simple valvular openings through the walls, or they may be connected with regular ventilating shafts; these shafts are often heated above or contiguous to heating or smoke flues so as to accelerate their ascending current.

A method of natural ventilation formerly common in our barracks and still advantageously used in the tropics, is ridge ventilation, the outlet consisting of an opening extending along the apex of the roof, protected by a screened hood against rain, flies and mosquitoes (Figs. 215, 216). With this system, 1-story barracks may be left unceiled for more perfect ventilation, but when 2-storied, ventilating shafts are used and made to open in the ridge under the hood.

In temporary barracks, or other buildings heated by stoves, ventilation is rendered easy by bringing fresh air in conduits to the jacketed stoves and providing for the escape of foul air by ventilating shafts through which pass the smoke-stacks (Fig. 135).

Chimneys, with or without fire, have a marked effect upon ventilation, causing an upward draft which increases proportionately with the difference between the temperature of the inside and outside air. Thus

OUTSIDE VIEW. INSIDE VIEW.

FIG. 130.—Ventilating panels. (*Mobile and Victor system.*)

Morin found that even without fire, but with a difference of temperature of 21° F., the chimney of his study evacuated 400 cubic meters of air per hour. This strong draft of chimneys is far from being always beneficial; it may produce objectionable currents along the floor and draw down the foul air from above. Chimneys should preferably have a separate supply of air from the outside, while the up-draft created by the fire can be utilized by placing a mica flap-valve in the flue just below the ceiling as an outlet for foul air.

The wind blowing horizontally upon or at right angle to the mouth of a

chimney or ventilating shaft causes a marked movement of aspiration up the flue or shaft, thus increasing its draft. The wind, however, is subject to so many disturbances in force and direction that it may also drive the air down and reverse the current. This is prevented by various cowls and ventilators so constructed that from whatever direction the wind blows and at whatever angle, it passes over the opening nearly horizontally, thus assisting the upward draft; besides, they protect the flue against rain and snow.

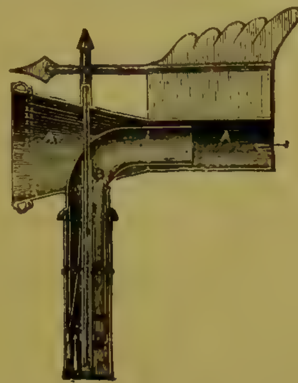


Fig. 131.—Rotating exhaust ventilator. (*Munson.*)

Fig. 131 shows the ordinary funnel-shaped ventilator revolving so as to always present the mouth of the funnel to the wind. Likewise revolving is the Ariel ventilator (Fig. 132) in which the wind is deflected over the mouth of the chimney so as to be always transformed into a horizontal draft. Fig. 133 is a fixed ventilator largely used in the construction of barracks and hospitals. The "anchor" ventilator is of the same fixed type and also efficient.

ARTIFICIAL VENTILATION.

Artificial or mechanical ventilation is obtained either by the direct propulsion of fresh air, through blowers or fans, into the building to be ventilated, the vitiated air being forced out by displacement (plenum system), or else by the aspiration of the vitiated air out of it (vacuum system), both systems being generally combined. The plenum system is commonly used in large public buildings, including hospitals. The process, briefly, is as follows: The air taken from a pure source is drawn, through filtering bags, to the fan in the basement, then forced into the heating chamber, where it comes in contact with steam coils and acquires the degree of heat desired, and thence distributed throughout the building. From the individual rooms, in which it diffuses itself, the air passes through the outlets into ducts which convey it to a central exhaust or extracting flue. In the vacuum or extraction system a strong up-draft is produced in the central flue by means of steam coils (acceleration coils) or an exhaust fan, or both. This system is rarely used alone as it causes fresh air to rush in from all sides below, and numerous drafts.

Artificial ventilation has decided advantages: It is more or less under control in all weathers; the air can always be drawn from a pure source, filtered and freed from dust, heated, cooled and moistened as desired.

Against it may be objected the difficulty of regulating its mechanism so as to obtain satisfactory results under all conditions, and the deterioration of the air as it passes from the fan, through the heating chamber and the extended ducts, to all parts of the building. The present tendency of sanitary engineers is to rely more than formerly upon natural ventilation and to utilize it as far as possible.

For purposes of ventilation and heating, two kinds of openings are provided, inlets for fresh air and outlets for foul air. Since the air entering through the inlets mostly escapes through the outlets, it follows that, from the position of these openings will depend the direction of the movement of

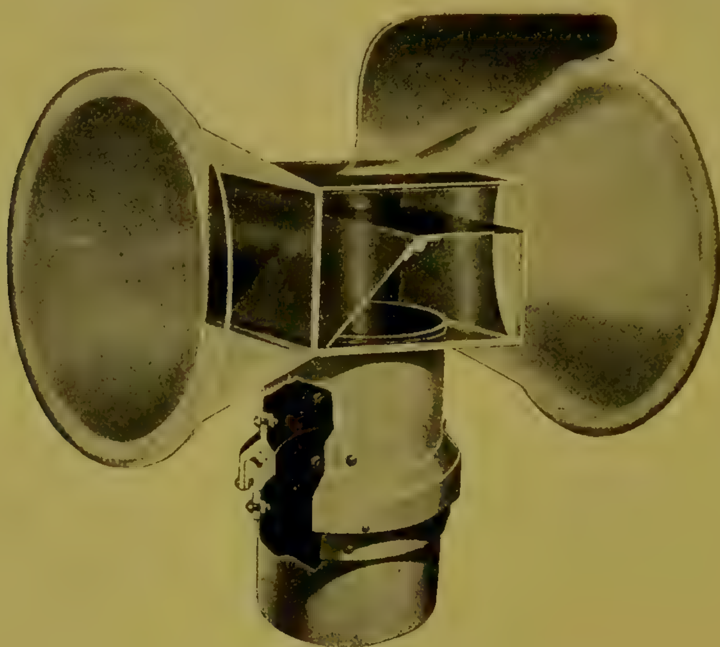


FIG. 132.—Rotating ball-bearing Ariel ventilator.

air, whether it will ascend, as in natural ventilation, or descend. Both upward and downward systems have their advocates; their relative merits may be thus summed up. Downward, or inverted, ventilation prevents the dust on the floor from rising and being breathed by the occupants; it produces a more thorough diffusion of the air with less danger of drafts. But, on the other hand, having to overcome the ascensional currents from the human bodies, as well as from all gas flames used for lighting, the quantity of air needed, and the power to extract it, are enormously greater than in the upward system, with proportionately increased cost. Furthermore, in large halls with galleries and amphitheatres, it is impossible to draw the air downward without exposing the people in the lower seats

to breathe the foul air descending from the upper tiers. It is also necessary for the successful operation of this system to keep the windows carefully closed, so that no supplemental fresh air can be directly admitted. As a general rule, therefore, and unless there is some special indication to the contrary, the natural upward system is to be preferred. It is the system used in the Capitol, Washington, D. C.

The position and size of inlets and outlets will be determined by the following considerations. The inlet registers should admit the requisite amount of air without currents of such velocity as would cause discomfort to the occupants. The larger the area of register openings, per person, the slower will be the movement of air passing through them. This area will accordingly vary accordingly to the location of the registers; for instance, if, in an assembly room, the fresh air is introduced through the floor, the total area of registers for each occupant should be at least 100 square inches, while it need not be more than 30 square inches if the registers are placed near the ceiling and a fan is used to ensure the requisite increased velocity. A good practical rule is to give each person no less than 30 square inches; this, with a velocity of 2 feet a second will deliver 1,500 cubic feet per hour. In most buildings, however, and always in our military barracks and hospitals, artificial ventilation is never exclusively relied upon but is largely supplemented by natural ventilation. A better distribution of air is obtained by providing smaller but more numerous inlets rather than larger and fewer openings.

FIG. 133.—Star fixed ventilator.

Cold, raw air is liable to produce unpleasant drafts and it is always advisable, in artificial ventilation, to warm it before admission to occupied rooms. This warming, however, must be moderate, never exceeding 55° or 60° F., so as not to deprive it from the freshness and invigorating qualities which are so readily affected by a higher temperature. Therefore, air admitted for ventilating purposes should not be depended upon for warming the building as, for instance, in that most objectionable method of heating, the hot-air furnace.

The incoming fresh air, to be most available, must diffuse itself thoroughly in the room so that it may be breathed by the occupants before it escapes. Inlets and outlets should therefore be as far apart as possible, or at least so situated that the entering air does not pass out through the outlets before it has served its purpose. Thus when the fresh air is warmed, the inlet registers should never be placed directly below the foul-air

registers, for direct currents would easily be established between them, with little effect upon the mass of air in the room. The inlets may be near the base of one wall and the outlets near the base of the opposite wall, the air becoming diffused while passing from one side to the other. If both inlets and outlets are in the same wall, the latter should be below the former; in such case a circulation is established from the inlets upward along the ceiling and across the room to the opposite walls, thence down to and along the floor to the outlets.

In our barracks and hospital wards the fresh air is generally introduced by valvular openings through the walls directly under the radiators (direct-indirect system), while the foul air escapes through outlets in the inside wall.

Whenever the air is warmed, inlet registers, especially if sufficiently large, may be near the floor without fear of draft; but, with cold air, they should be above the heads of the occupants (winter or summer), that is to say, about 6 feet high and so shaped as to deliver the air in an upward direction. Very often two outlets are placed on the same shaft in a room, one below for winter use and the other above, near the ceiling, for the natural ventilation of summer. Fresh-air registers, if placed on the floor. should not be flush with its surface, for dust and dirt will fall into the flues and be more or less returned with the ascending air. It is also necessary that each room should have its own fresh-air flue separate from all other flues; thus two or more rooms above each other should never be supplied from one common flue.

Draft.—What is generally called a draft in a house is an air current colder than the air surrounding the body; therefore it is not felt in the open, where the temperature of the air, whether still or in movement, is everywhere practically the same. A draft is most likely to be felt when sitting indoor and remaining for some time in the same position, the current striking only a limited part of the body. This part becomes insensibly cooler than the rest, with depression of its nerve supply, a condition which may react upon some of the sensitive organs of the body. It is to be noted that the same draft blowing over the entire body is less likely to do harm. Windows being generally colder than the walls of a room chill the air in contact with them, with production of a cold downward current; therefore the near vicinity of windows is to be avoided by persons sensitive to drafts, especially in winter.

CHAPTER XXVIII.

HEATING.

Heat, whether evolved from the combustion of fuel or from any other source, is transmitted by conduction, radiation and convection:

By conduction when it passes from one particle of matter to another in contact with it as, for instance, in a poker one end of which is in the fire. Substances vary much in their conductive power; metals are much better conductors than wood, stone or glass. Liquids and gases are poor conductors but heat passes readily from them to solids, and conversely. All textile fabrics containing much air, such as furs and flannels, have likewise a low degree of conductivity. The following common substances are placed in order of their conductive power: copper, iron, lead, slate, glass, water, brick, asphalt, wood, wool, air, asbestos. Conduction plays a part, more or less important, in all methods of heating.

By radiation when it reaches bodies directly exposed to it through the intervening air, like the solar heat or that emanating from an open fire. It is propagated in straight lines in all directions with equal intensity, the effect lessening according to the square of the distance. The air, especially if dry, is but little affected by these radiant rays; the objects which they reach absorb and reflect them and, in their turn, disseminate the heat by conduction and convection.

By convection when, in liquids and gases, it progagates itself through the mobility of their molecules, those in direct contact with the source of heat becoming expanded, therefore lighter and rising up, while others descend to take their place, so that ascending and descending currents continue until the whole mass of liquid or gas is evenly heated. Convection plays the chief part in the distribution and equalization of heat in an apartment. All sources of heat as well as heated objects in it, warm the air in immediate contact with them and thus establish convection currents, the air remaining in active movement until complete diffusion and an even temperature are obtained. In an inhabited room, each person is the source of a convection current, the heated vitiated air rising from the body, to be replaced by cooler and purer air.

SUITABLE INDOOR TEMPERATURE.

In winter, the temperature of houses, offices and hospitals should be from 68° to 70° F. In barracks, factories, schools, churches, or wherever many people assemble, it should range from 65 to 68°, while in gymnasiums, drill halls, etc., where active exercise is taken, it must not exceed 55°. In summer, a natural temperature of 65° is quite comfortable. In England, the winter temperature recommended for houses is from 62° to 65°, a difference mostly due to the greater amount of moisture in the British Isles.

As the air of a room becomes heated, its capacity to hold moisture is greatly increased and its relative humidity accordingly diminished. In other words, it becomes drier, and if no moisture is added by artificial means it will absorb it from the persons, furniture and all objects in the room; from the skin, which becomes hard and rough; from the mucous membranes of the mouth, nose and bronchi, causing irritation and cough; and from plants which will dry up and wither. The necessary humidity, therefore, must be furnished so that it may not fall too far below that of the outside air. In the eastern and middle States the relative humidity of the air is from 65 to 70 per cent. In England it is about 75; in Germany, from 50 to 60, and in our arid western territories, 40 to 50. The relative humidity of rooms artificially heated, in this country, is seldom more than 30 to 40. This should be brought up to at least 50 for the requirements of the healthy body. The nearer it is to the degree of moisture of the outside air the more pleasant it will feel and the lower the degree of heat which will be necessary; thus Dr. Barnes, of Boston, while keeping his office at 53 per cent. relative humidity (by the use of a cotton wicking "humidifier"), found a temperature of 65° F. to be perfectly comfortable instead of 70° as before required (Harrington). The difference between the wet and dry bulb thermometers should never be less than 4° nor much more than 5°.

Moisture is imparted to the air by placing pans of water, cotton wicking dipping in water, or moist towels, etc., in heated currents or over stoves and radiators.

METHODS OF HEATING.

Houses, barracks and hospitals, as well as all other buildings, may be heated by open fire or grate, stove, furnace, hot water and steam.

Open Fire or Grate.—The heat is transmitted chiefly by radiation so that a person facing the fire may be quite cold in the back. Most of it passes up the smoke flue and is lost. This method, therefore, although pleasant

and cheerful is quite wasteful. Much air is drawn into the room by the aspiration of the chimney, but it passes mostly along the floor, causing drafts and not diffusing itself. There are ways, however, of utilizing open fires and grates for better heating and ventilation, as, for instance, that shown in Fig. 134 in which fresh air, warmed by the fireplace and smoke flue, enters above and, after diffusing itself in the room, is drawn up through the hearth.

Stoves.—Stoves heat by radiation and convection. They are the most economical and efficient mode of heating, utilizing from 80 to 90 per cent. of available caloric. On the other hand, they are noisy and dusty; they dry the air to a trying degree and scorch the organic particles floating in it,

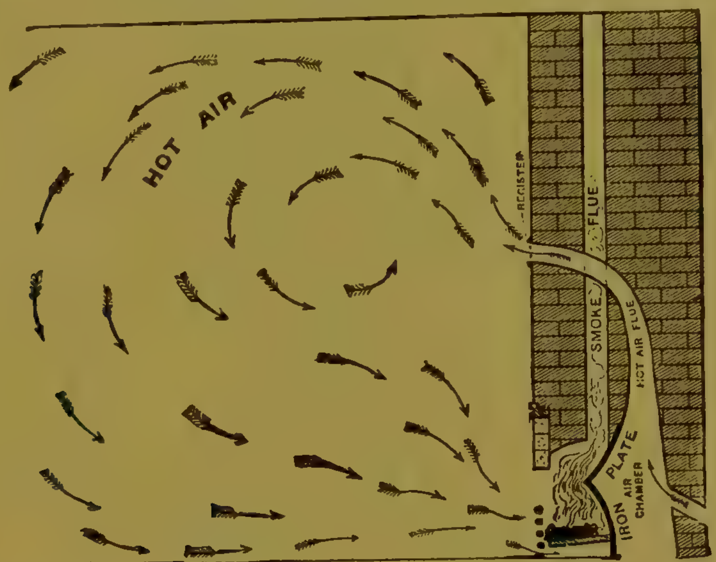


FIG. 134.—Method of heating and ventilating by open fire.

injuring its respirable qualities and causing unpleasant odors. A red-hot cast-iron stove may also permit the highly poisonous carbonic monoxid to pass through it. There is likewise danger, if the damper is closed or the draft otherwise imperfect, of gases escaping from it. These objections, however, can to a large extent be remedied by careful management. The ease with which stoves can be utilized for ventilation is one of their advantages. Thus Fig. 135 shows how barracks can be heated and ventilated by the simple device of surrounding the stoves with a sheet-iron jacket which keeps the cold incoming air (brought under the floor from the outside) long enough in contact with the metal to warm it to a suitable temperature. The stovepipes run into and out of a ventilating shaft; but if the latter is capped with a star ventilator (a preferable method) the pipes terminate under it. The shaft must have two outlets, one below, near the

floor, the other above, near the ceiling. Whenever the stoves are used, the upper outlet is closed and the lower open so that the heated fresh air, after ascending, is compelled to diffuse itself downward to escape through the shaft. The upper outlet is used in summer to promote natural ventilation, and, occasionally, in winter when the foul air accumulates faster than can escape through the lower vent. Fig. 136 shows an excellent type of the so-called ventilating stoves in which the fresh air is brought in contact with the fire-box before diffusing itself through the room.

As an improvisation, for winter quarters, especially where fuel is scant, the "Russian stove" deserves to be better known. In the field it consists

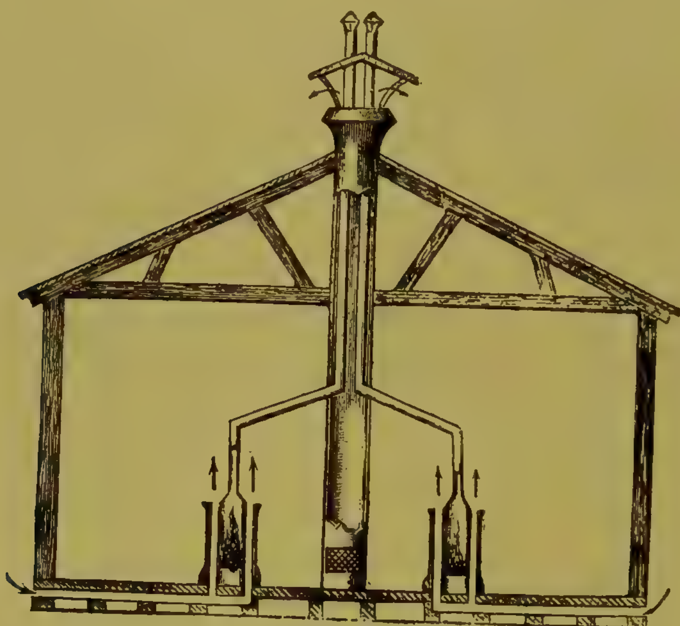


FIG. 135.—Diagram showing the use of stoves to heat and ventilate barracks.

simply of a substantial brick, stone or clay structure through which the flue is made to describe several vertical curves so as to impart its heat to the whole mass. Once heated, very little fuel is required to maintain its temperature. Such stove is never very hot, therefore does not unduly dry or char the air and gives off a pleasant, even, steady, moderate heat.

With all kinds of stoves it is very important to see that a sufficient degree of humidity in the air is maintained; most of them are provided with receptacles for water and these should always be kept full; but they are generally insufficient and additional water-pans must be used.

Hot-air Furnace.—In this method, the air is heated in a furnace in the basement and conducted by means of large galvanized iron pipes to all parts of the building. It has but little to recommend it except cheapness

of installation, which may have to be considered in private dwellings. It both heats and ventilates. The ventilation is promoted by providing enough outlets for a proper air movement; this movement being outward, drafts from the outside air are prevented. The disadvantages of the method are serious: The heat is unevenly distributed, its diffusion depending upon the direction of the wind so that the windward side of the house may be cold and the other side too warm, and depending also upon

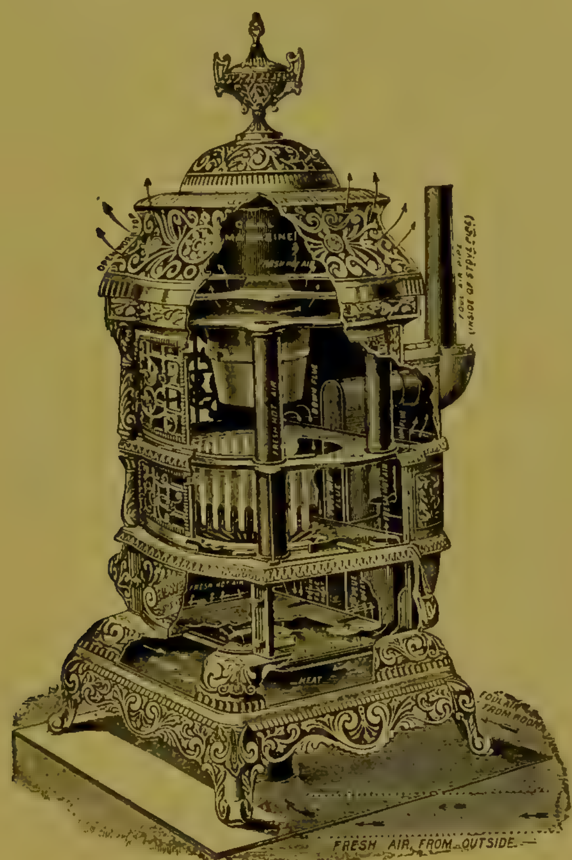


FIG. 136.—Cortland Howe ventilating stove.

the length, slant and angles of the pipes, the heated air passing readily up vertical pipes but quite slowly along nearly horizontal and crooked ones. The air, which is in somewhat prolonged contact with the hot furnace, is necessarily scorched and carries more or less dust with it, so that it is often quite irritating to the throat and nasal passages; in case of any crack or leak in the furnace, it becomes dangerously contaminated with coal gas.

HOT WATER.—This method of heating, whenever applicable, is the most satisfactory for houses, barracks, hospitals and public buildings. The

high specific heat of water makes it an excellent medium for the storage, transportation and distribution of heat. The quantity which can be stored in equal weights of water and air is in the ratio of 421 to 100, which means that the heat set free by one pound of water, cooling down one

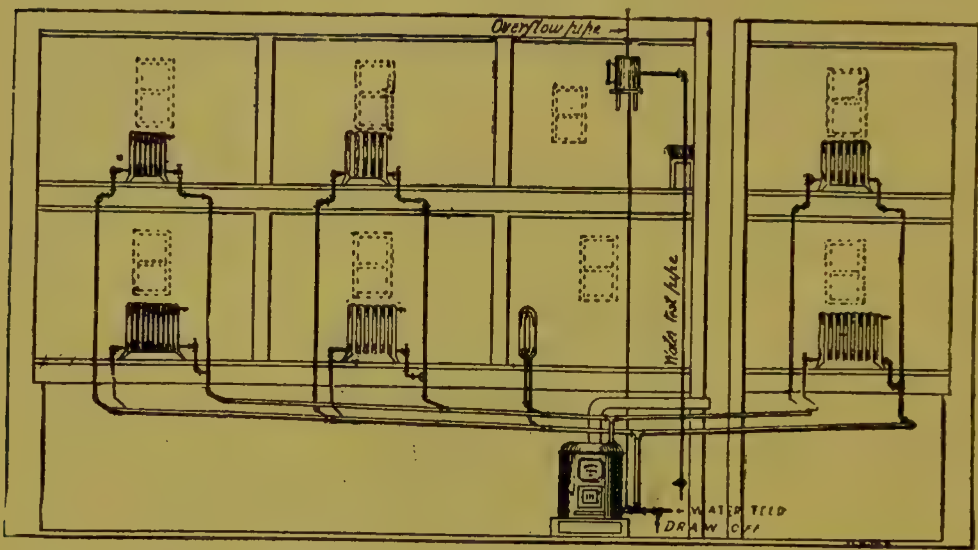


FIG. 137.—System of piping for hot-water heating—Main flow- and return-pipes. ("Heating and ventilating buildings."—*Rolla C. Carpenter.*)

degree, will raise 4.21 pounds of air (or 55 cubic feet) one degree. In practice, it is estimated that one cubic foot of water, cooling one degree, will raise to that extent the temperature of 3,000 cubic feet of air.

The low-pressure system is practically always used, being safer and more

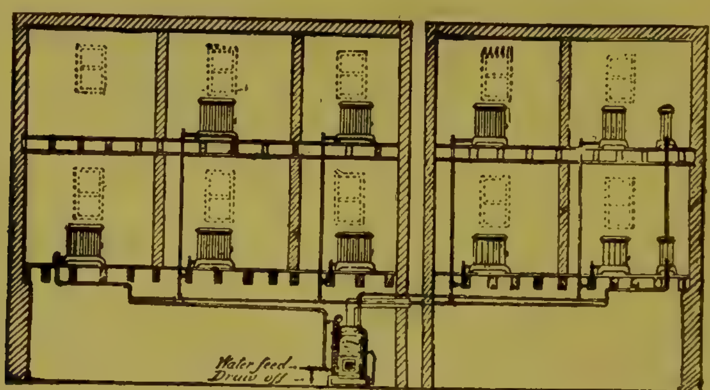


FIG. 138.—System of piping for steam heating. (*Baldwin.*)

easily controlled than the high-pressure one. From the boiler, in the basement, a set of pipes convey the hot water to all the radiators in the building and a second set return the cooled water to the bottom of the boiler (Fig. 137). The system is open above, at its highest point (expansion tank), so

as to provide for the expansion of the water, and a vent is provided on each radiator for the escape of dissolved air liberated from the water. The temperature of the water averages 180° and seldom reaches 212°. The heat, as transmitted from the coils, by conduction and convection, is pleasant, equable and constant, not liable to rapid changes. The system is noiseless, very easily regulated, devoid of danger and, after the first installation, cheaper than steam heating.

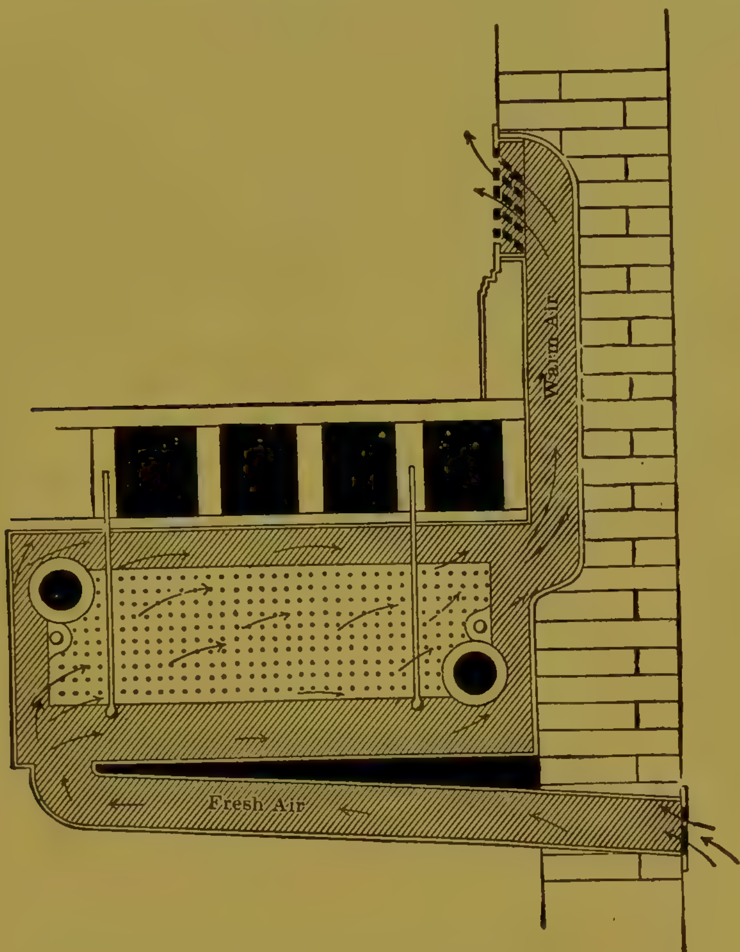


FIG. 139.—Indirect system of heating. (*Bashore's "Outlines of practical sanitation."*)

STEAM.—Steam is still more efficient than water as a medium for the absorption, storage and transmission of heat on account of the enormous quantity of latent caloric which it sets free on condensing. Thus one pound of steam condensing to boiling water gives off enough heat to raise the temperature of 22.5 pounds of air, or 5.36 pounds of water, to 212°. Steam has been more generally used than hot water in this country because of the cheaper and easier installation. The coils are smaller, more

compact and no return pipes are required (Fig. 138). The heat can be turned on or off much more rapidly, and by dividing the coil in several sections, as many sections are used as needed to obtain the exact degree desired. As the temperature in the pipes seldom exceeds 225° there is no danger of scorching the air. An advantage of steam over hot water is that it travels great distances with rapidity and without condensation provided the mains are sufficiently large and well insulated. It is also much more efficient for the heating of the upper stories of tall buildings. It is likewise preferable in very cold countries, being much less affected by a tempera-

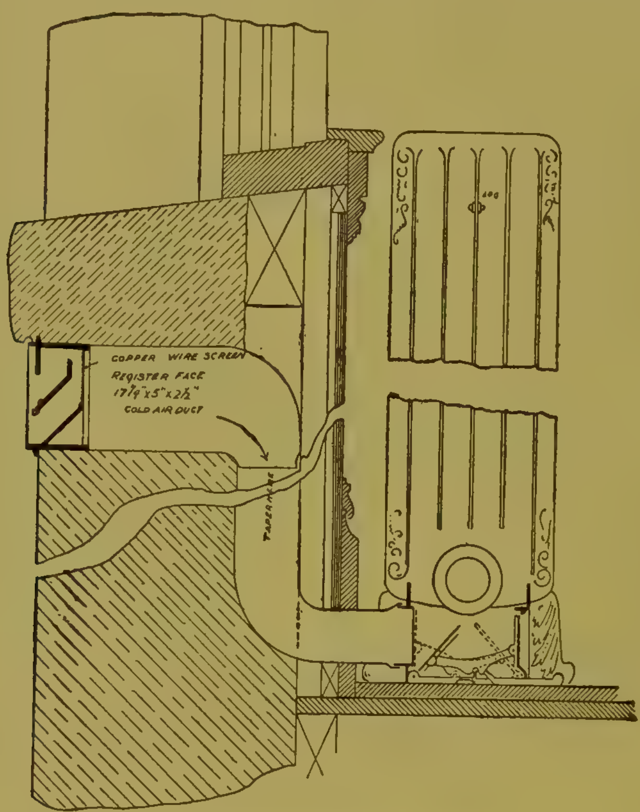


FIG. 140.—Direct–indirect system of heating. (*Munson.*)

ture below zero. The chief defect of steam heating is the socalled "water- hammer," a loud percussion noise produced whenever condensation water forms in the coils, and the steam, forcing its way, projects it against the sides of the pipes.

Location of Coils.—With either hot water or steam, the location of the coils, within the room, does not matter much, depending upon its shape and the disposition of the furniture. Generally they are best placed under the windows so as to be out of the way and, at the same time, warm the cold air leaking through or flowing down from the chilling panes. It is

also the best place to receive the cold air from ventilating inlets as is commonly done in our barracks and hospitals.

It should be remarked that the designation of radiators, given to heating coils, is a misnomer inasmuch as they heat mostly by conduction and convection, and least by radiation.

SYSTEMS OF HEATING.—It has been seen that the source of heat can be in the room itself, and not directly connected with ventilation, as with common stove, open fire or grate, steam or hot water radiator; this is the *direct* system. When the air is heated before entering the room, either through a hot-air furnace or by passing over steam coils, and is used for heating and ventilation, the sytem is said to be *indirect* (Fig. 139). In the *direct-indirect* system, the source of heat is in the room and the air supply is brought in contact with it, as in the case of jacketed or "ventilating" stoves, and of hot-water or steam coils with cold-air inlets introduced under them (Fig. 140).

As has already been stated, it is desirable that the incoming fresh air, in winter, should be moderately warmed before entering an occupied room. When the building is heated by hot water or steam, the air may be admitted through the walls directly to the coils (direct-indirect system), in which case it abstracts some of their heat so that more coils are required; or else the air is passed over steam coils in the basement and introduced into the room through a sufficient number of registers (indirect system), in which case it brings additional heat to that furnished by the coils.

CHAPTER XXIX.

LIGHTING.

Light is necessary to the growth and development of animals and plants. Upon animals it favors metabolism, improves the quality of the blood and promotes the performance of all functions. With the exception of the lower cryptogams, plants thrive only under the influence of light; it is only under such influence that they perform the all-important nutritive function, through their green foliage, of decomposing the carbon dioxid of the air, appropriating the carbon and giving off the oxygen. But light, on the other hand, is inimical to low forms of fungi, including all microbes and bacteria, inhibiting their growth or killing them outright. Therefore it appears that while strengthening man, sunlight destroys some of his silent foes, the pathogenic micro-organisms. Hence the necessity of a sufficiency of window surface in all buildings; this surface should be equal to at least one fifth of the floor area, or one square yard for each 30 cubic yards of space. In cold or temperate climates, the windows should be disposed on at least two sides of the buildings so that the sunrays, if possible, may reach all parts of the floor. This is especially desirable in buildings occupied by many people, such as barracks, schools, factories, etc.

In thus providing light and sunshine it is very important to consider the climate and season. The calorific and luminous properties of the solar rays are stimulating and, to a certain point, necessary for the proper work of the bodily functions, but, beyond that point, they become depressing and harmful; for instance, the sunlight which is cheering and invigorating in winter may be intolerable and dangerous in summer. In tropical countries, the sun, during the hot season, is often the worst enemy that the white man has to encounter and measures must be taken, not to exclude it altogether, but to mitigate its unpleasant effects. Therefore the houses should face north and be protected, at least on the south and west sides, by broad verandas. Not only the sunrays should be excluded, but the diffused light itself, when very bright, must be subdued. Dazzling white surfaces are particularly objectionable and, in warm climates, the law should require that all walls be lightly tinted.

Location of Lights.—In the study- or class-room, the reading or writing desk should be placed so as to be clearly lighted, free from shadow and glare. Since reading and writing are from left to right, it is best to have the window on the left so that no shadow be projected on the book or paper. It must not be in front, for every time the eyes look up through it, at any outside object, there is a change of focusing accommodation, followed by another as soon as the reading or writing is resumed, causing fatiguing eye-strain. Artificial lights should be white, bright and steady; they may be placed on the left or in front, so that no shadow shall be thrown upon the field of vision, and must always be shaded in order to concentrate their power and protect the eye.

Use of Prismatic Glass.—When a room is lighted only by front windows, its rear part can be rendered much brighter by the use, in these windows, of prismatic- or ribbed-glass panes which refract the luminous rays in a horizontal direction and light up all parts of the room, if not too deep.

ILLUMINANTS.

The illuminants most generally used are candles, petroleum, coal gas, acetylene and electricity. With the exception of electricity, they all absorb oxygen while burning, and give off carbon dioxid, vapor of water and other products of combustion which pollute the air.

In all illuminants, luminosity or their lighting power is to be distinguished from their heating power. During their combustion, the hydrocarbons, of which they are largely composed, break down and set free the hydrogen and multitudes of carbon particles. In an ordinary flame, the oxygen of the air is not sufficient to combine at once with all these constituents. As the carbon particles pass outward through the flame of the burning hydrogen, they are not oxidized but so much raised in temperature that they become incandescent, thus causing the luminosity of the flame; as they reach the edge of the light they are converted into carbon dioxid. Whenever it is possible to furnish enough air to the flame, as in the Bunsen burner, to combine with all its constituents at once, the carbon particles are converted into carbon dioxid as soon as set free, producing an intense heat but no luminosity.

Candles.—When necessary for the public service and illuminants are not otherwise furnished by the Quartermaster's Department, the Subsistence Department may issue candles in the proportion of 24 ounces to each 100 rations, or 32 ounces in Alaska. Lantern candles are issued in such quantities as the commanding officer deems necessary.

Petroleum, when properly used, is an excellent illuminant, giving a soft bright light, without objectionable odor or poisonous properties. It is still largely burned at many of our military posts, although being gradually replaced by gas or electricity.

GAS.—The ordinary coal gas, made by heating bituminous coal in fire-clay retorts, consists chiefly of about 50 parts of hydrogen, 35 of carbureted hydrogen (marsh-gas) and 6 or 7 of carbon monoxid. Water-gas, now extensively used, is made by the action of steam upon coke or anthracite coal heated to a very high temperature; the steam is decomposed and its oxygen combines with the carbon to form carbon monoxid. This gas is usually carburetted, that is, passed through hot chambers charged with petroleum where it absorbs a supplement of carbon to increase the luminosity of its flame. Water-gas contains about 35 parts of hydrogen, 30 of carbon monoxid and 20 of marsh-gas. In whichever way prepared, gas is very poisonous owing to the carbon monoxid it contains; water-gas containing four or five times more of it than ordinary coal gas is proportionately more dangerous; its odor is also much less pronounced so that its presence, from leakage or open burners, is not so readily detected (see page 305). As its use has become more general during the last fifteen years, the number of deaths caused by it, accidental and suicidal, has increased so rapidly that the enactment of legislative measures to restrict the amount of the deadly carbon monoxid to a safe proportion (less than 20 per cent.) would seem to be clearly in the interest of every community.

The usual products of combustion of gas, besides carbon dioxid and vapor, are small amounts of carbon monoxid, ammonia and sulphur compounds. Furthermore, each cubic foot of gas, in burning, generates enough heat to raise the temperature of 1,160 cubic yards of air 1°.

Burners have been devised to increase the luminous intensity of the flame with smaller consumption of gas, therefore with less vitiation and heating of air. Such are the so-called "regenerative burners" in which the gas is mixed with hot air, that is, air heated by the flame itself. The most satisfactory, however, are the incandescent burners and, of these, the Welsbach is the best known and most used. It consists of the ordinary Bunsen burner, over the flame of which is hung a mantle of incombustible material. This mantle is usually made by saturating a delicate network of cotton in a strong solution of earthy oxids. When heated by the Bunsen flame it becomes incandescent and intensely luminous, a remarkakle instance of heat transformed into light. The Welsbach burner consumes nearly one-half less gas than the ordinary burners, producing there-

fore only one-half the heat and half the amount of carbon dioxid, while its illuminating power is at least three times that of the incandescent electric light.

Acetylene.—This gas is obtained by the action of water upon calcium carbide. It gives a very brilliant white light, with an illuminating power about equal to that of the Welsbach incandescent burner. It requires a special burner consisting of two tips, each with a minute orifice or slit, the

Fig. 141.—Acetylene outfit for field hospital. (*Colt system.*)

two opposed jets forming a small thin flame able to secure enough oxygen for the complete combustion of the gas. Carbonization, however, is liable to occur on the tips and obstruct the orifices. Acetylene, notwithstanding its very unpleasant odor of garlic, is not as poisonous as coal gas. When mixed with air there is danger of serious explosion in contact with light, so that care must be taken that the piping and fittings are tight and sound.

The advantages of acetylene, besides its intense illuminating power, are its cheapness, being the least expensive of all illuminants, and the facility with which it can be produced in any place. It is especially valuable for military purposes on account of the portability, simplicity and ease of operation of the generator. In our service, a small but complete acetylene outfit, consisting of generator, rubber piping, burners, reflectors, etc., weighing, with chest, 74 pounds, is supplied to each field hospital for the lighting of the operating and dispensing tents (Fig. 141). Two such outfits are allowed a stationary hospital and three to a base hospital. The generator, of about the size of a water pail, contains two pounds of carbide and can maintain four 25-candle-power burners for four hours, before being resupplied. Fig. 142 shows the application of the system to a

FIG. 142.—Hospital tents lighted with acetylene gas. (*Colt system.*)

hospital ward under canvas. Small acetylene lamps, secured in front of the cap by an elastic band, to be used at night by hospital corps men in searching for the wounded and other purposes, have also been experimented with and found very satisfactory.

Electricity is the ideal illuminant and should always be preferred when available. Used in the form of the incandescent lamp, it gives a white, steady, brilliant light of at least 16-candle power. As this light is not the result of combustion and does not absorb oxygen from the air, no contaminating product is given off and the composition of the air is in no way affected. Its feeble heating power renders it particularly valuable for

tropical climates, but less desirable than gas where lights are depended upon to create an upward ventilating current.

The respective cost of illuminants, for each candle power, per hour, is estimated as follows: Tallow candle, 4 cents; gas, bat's-wing burner, 0.76 cent; electric incandescent lamp, 0.60; petroleum, 0.54; Welsbach incandescent gas lamp, 0.32; acetylene, 0.20.

CHAPTER XXX.

DISPOSAL OF EXCRETA, GARBAGE AND WASTES.

By excreta must be understood all waste matters, solid and liquid, eliminated from the human body, such as feces, urine, sweat, as well as discharges from the mouth, nose and lungs. Garbage refers chiefly to kitchen refuse, including much animal and vegetable matter in the shape of food débris. The waste waters which hygienists are most concerned with are those from kitchen sinks, lavatories, baths and laundries.

The average daily discharge of fresh fecal matter, per male adult, is 5 ounces, and of urine 45 ounces. In a mixed community, including men, women and children, the average per head may be estimated at 3 ounces of feces and 32 ounces (1 quart) of urine. Fecal matter contains 75 per cent. of water and 22 per cent. of organic substance of which 2.2 is nitrogen. Urine contains 95 per cent. of water and 1.4 of nitrogen. Feces are quickly putrescible, their decomposition often beginning before being discharged, owing to the agency of the saprophytic microbes which swarm in them. These microbes bring about their transformation into simpler harmless substances and therefore play a useful part in the economy of nature; but excreta may also contain pathogenic bacteria of various kinds and, on that account, are always open to suspicion.

SEWERAGE AND PLUMBING.

The general system whereby excreta and wastes are removed by water through fixtures, pipes and drains into sewers or other place of final disposal, is called sewerage; while the name of sewage is given to the contents of drains and sewers.

Sewage in this country is generally largely diluted, seldom containing more than one part of organic matter and one of mineral per 1,000; it is therefore, practically, water more or less polluted, and its amount can be readily estimated from the consumption of the water-supply. Of the matters in suspension, 50 to 75 per cent. are organic and the remainder mineral. Of the organic matter, only 2 or 3 per cent. is nitrogen, the larger proportion consisting of carbohydrates and fats.

A good sewerage system requires an abundant water-supply for the flushing of fixtures and drains, with sufficient outfall and effective means

of final disposal; it must be well and substantially constructed, of excellent material, perfectly water-tight and thoroughly ventilated.

The marked effect of sewerage upon human health has long since been conclusively demonstrated. The excreta likely to contain the germs of typhoid fever, dysentery and cholera are carried to a safe place of final disposal instead of lurking in pits, vaults and cesspools; furthermore, many of the dangerous waste waters that would otherwise be thrown into yards or leaky receptacles also find their way to the sewers, with resulting improvement in the cleanliness and dryness of grounds. It is a well-known fact that the construction of a sewerage system in a city is immediately followed by a decrease in its mortality and that, next to the introduction of a pure water-supply, it is the most important factor in reducing the death-rate of infectious diseases, especially of typhoid fever which, of them all, is the one that most readily responds to sanitary improvements.

The popular fear of sewer air or emanations has been shown to be groundless. This air contains more CO_2 and organic matter than pure outside air, but fewer micro-organisms, in fact much fewer than are found in dwellings. Bacteria abound in sewage but hardly ever find their way into the air above it, so that sewer air is incapable of conveying typhoid fever or, so far as known, any other infectious disease. It is a matter of record that men working in sewers are strong and healthy, and have a low death-rate. Plumbing fixtures properly trapped completely exclude sewer air, so that if foul smells are noticed they are almost always due to the decomposition of excreta or other organic matter within the fixtures, pipes or traps. Such smells may produce headache and affect the appetite and digestion, and therefore are to be avoided, but seldom have serious or dangerous effects.

The plumbing system of a dwelling consists of fixtures (closets, lavatories, sinks, tubs, etc.), waste pipes, traps, soil pipe and drain (Fig. 143). The waste pipes connect the fixtures with the soil pipe. They are generally of lead on account of its malleability, but when too many bends are not required iron is preferable. They must always be readily accessible so that leakage be easily discovered and repairs made. Their diameter should seldom exceed 2 to 3 inches in order to secure a rapid flow and thorough scouring. The soil pipe is a cast-iron vertical pipe, 4 inches in diameter, into which the waste pipes empty the contents of the fixtures. Its segments, 5 feet long, each with spigots and hub ends, are carefully and strongly jointed by gasket of oakum and well-caulked molten lead. It should extend clear through the roof and project about 2 feet above it. At the bottom it must be firmly supported to prevent sagging, and make a

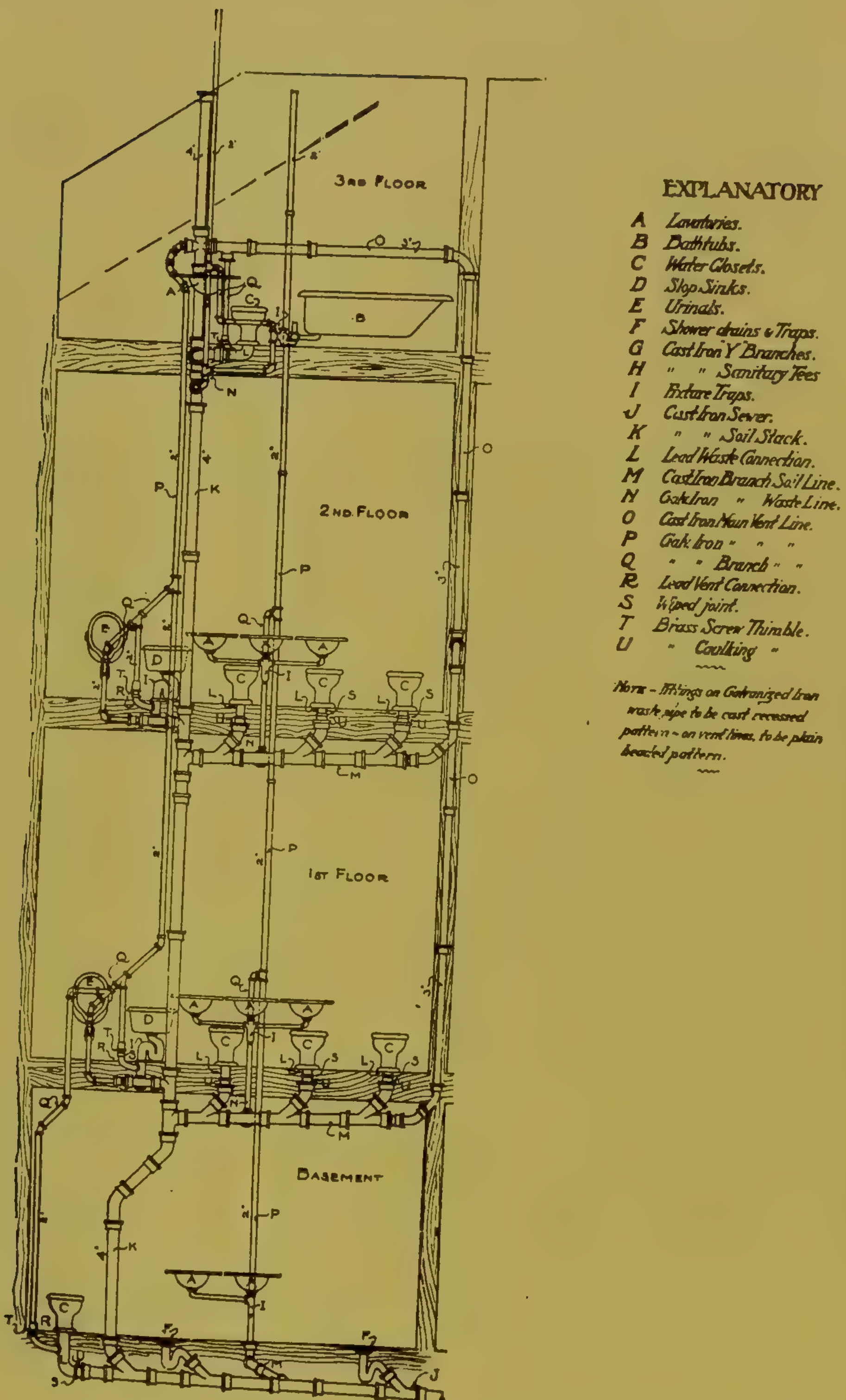


FIG. 143.—Plans and elevation of typical main soil stack with fixtures and connections, for standard 36-bed post hospital building.

wide bend at its junction with the drain. The drain forms the continuation of the soil pipe; it is also mostly of cast-iron, its diameter depending upon the number of soil pipes emptying into it. It should have as much slope as possible, and, before passing out of the house or just outside of it (within a manhole), be cut off from the sewer by an "intercepting" or "disconnecting" trap. The soil pipe and drain are thus thoroughly ventilated from above and below.

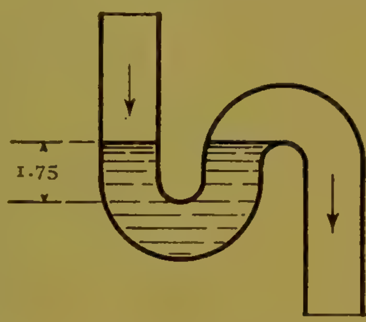
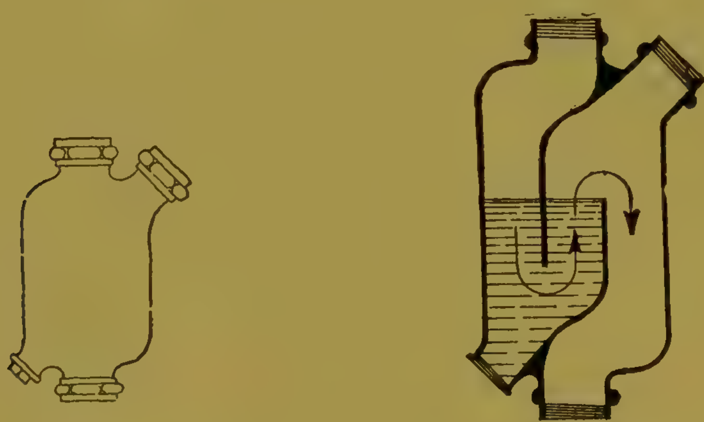


FIG. 144.—Common S-shaped, round-pipe trap.

TRAPS.—It is a rule that each plumping fixture must be guarded by a trap, that is to say, a device which while permitting the free passage forward of liquid and suspended matter to the soil pipe, prevents the passage backward of all air, gas or odor. The trap should be as near the fixture as possible and admit of easy inspection and cleaning. The common form consists of an S-shaped bend, filled with water, in the fixture or waste pipe (Fig. 144). As the fixture is flushed, the excreta are forced through the trap, with enough water to clean and scour it and afterward refill it to the proper level. The depth between the level of the water and the lowest point of the upper bend is called



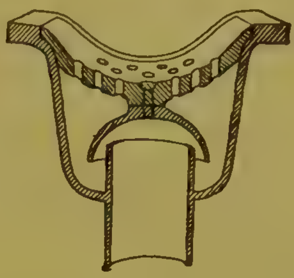
Outside view. Vertical section.

FIG. 145.—Flask trap. Quartermaster's Department type.

the seal (Fig. 144). This is generally 1 3/4 inches. The greater the seal the more complete its efficiency but the less perfect is the scouring of the trap.

The *round-pipe trap* is readily flushed and, being perfectly smooth, keeps itself clean, but loses its seal easily. The *flask-trap* (Fig. 145), com-

monly used in barracks and hospitals, is simple, durable, not easily siphoned out and easily cleaned. The *bottle-* or *pot-traps* contain much water and seldom lose their seal but require frequent cleaning. In the *ball-trap*, which is one of several obsolete mechanical types, the water displaces a



Outside view. Vertical section.

FIG. 146.—Bell trap. Quartermaster's Department type.

ball which, by its weight, falls back upon the outlet. The *bell-trap* is a form often used in kitchen sinks, areas and gutters, consisting of a reservoir containing water to the level of the outlet pipe; a bell covers the mouth of the pipe and dips into the water (Fig. 146); it is fastened to the strainer and removed with it to clean the reservoir. The waste, after passing through the strainer, reaches the reservoir and overflows into the outlet. The *floor-trap* (Fig. 147) used in mineral floors requiring washing, as in bath-rooms, operating-rooms, etc., is fitted with a strainer and sunk flush with the floor; it contains a bent partition with plug for clean-out. The *disconnecting* or *intersecting trap* is used to separate the outside drain or sewer from the house system. It has a fresh-air vent, as well as inspection and clean-out holes. Fig. 148 shows the one advocated by Harrington, in which the outlet (S) is lower than the inlet in order to secure freer outflow, and the fresh-air pipe (F) is placed far enough from the trap not to become soiled by the splashing filth.

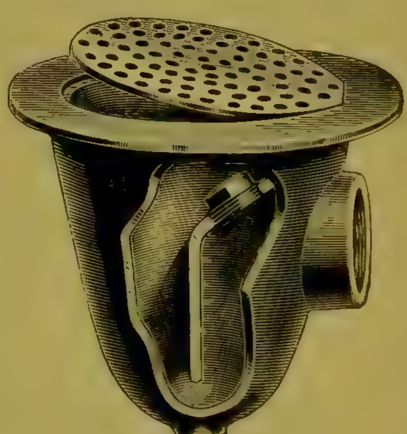


FIG. 147.—Floor trap.

Grease-traps are intended to congeal and collect the liquid fat contained in the warm waste waters of large kitchens and which, were it allowed to

escape, would solidify on cooling and eventually choke the pipes. One of the most efficient is the Tucker Improved (Fig. 149). Its essential feature

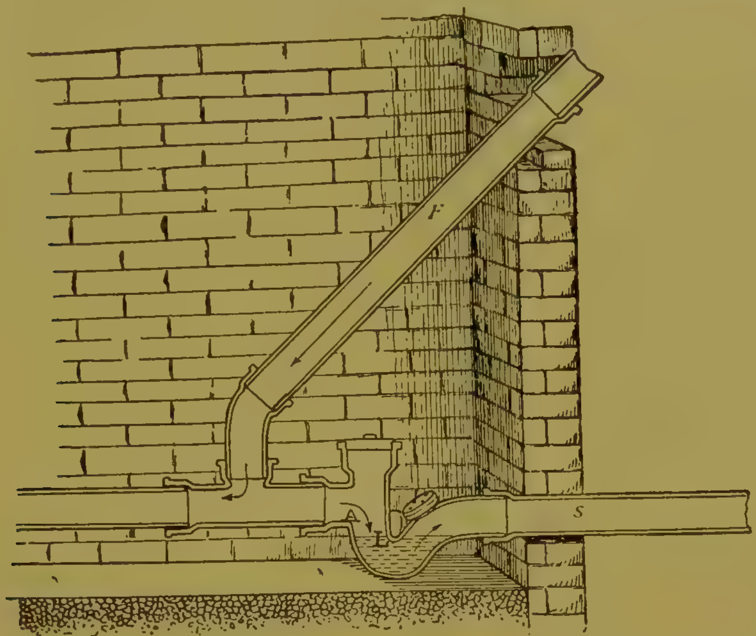


FIG. 148.—Improved intercepting trap. (*Harrington.*)

consists in being lined with a chilling chamber which also projects upward across it. The entire cold water-supply passes through this chamber

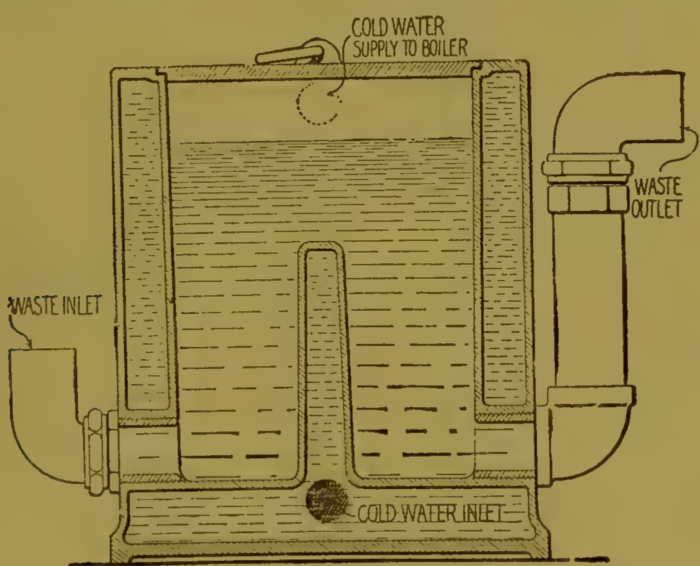


FIG. 149.—Tucker improved grease trap.

on its way to the boiler and sink, so that the trap is always kept cool. The flow of greasy water is deflected upwardly by the hollow partition,

the grease remaining at the surface while the water passes freely to the waste outlet on the other side. The congealed grease forms a scum easily removed from the top. Grease-traps should always be in a cool place, generally outside the kitchen. In the absence of such a trap, a strong solution of lye should often be thrown into the sink so as to saponify and dissolve the incrusting fat.

Loss of Seal.—Traps are exposed to lose their water seal and thus become useless, by siphonage, back-pressure, evaporation, capillary attraction, leakage and accumulation of sediment. The most frequent and important of these causes is siphonage; it results from the rapid discharge, with great momentum, of the mass of water from the trap without enough after-flush to refill it, or from the suction produced by a heavy column of water falling down the soil pipe. In loss of seal by back-pressure, which

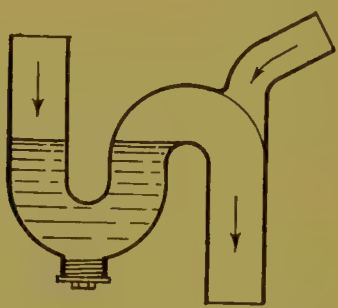


Fig. 150.—Vent pipe properly placed.

Fig. 151.—Sanitas trap.

is uncommon, the process is reversed; the column of water falling down the soil pipe and meeting with an obstruction, the compressed air is forced up the waste pipe and breaks the seal. The water of traps, especially vented traps, evaporates more or less rapidly according to the temperature and the movement of the air, so that when a fixture remains unused the seal is soon lost from this cause. It is therefore necessary to flush the fixtures of a vacant house once a week or, preferably, pour oil or glycerine into them. Capillary attraction may empty a trap by means of a rag or string lying partly in the water and partly over the bend into the outlet.

Siphonage, as well as back-pressure, are prevented in either of two ways: by a vent connected with the upcast branch of the trap, on the distant side of the seal, or by the use of a non-siphoning trap. The vent supplies air to the waste pipe on the distant side of the trap and thus prevents the formation of any vacuum which would cause the suction and destruction of the seal; in case of back-pressure it affords an exit to the compressed

air. The vent pipe should preferably be placed, not on the summit of the curve but a little below, so that the sewage may not be projected into it (Fig. 150). Each vent pipe, from the various fixtures of a system of plumbing, connects with a main ventilating pipe which, usually, runs alongside the soil pipe, both projecting above the roof; there is no objection to their being connected, provided such connection be made above the highest fixture (Fig. 143).

FIG. 152.—Anti-siphon trap. Quartermaster's Department type.

Non-siphoning Traps.—These have been devised to obviate the necessity of back-venting which is expensive and sometimes causes rapid evaporation of the seal. They are all so constructed that air may be drawn through them by suction without loss of much water, a sufficient volume of it remaining to reform the seal. Among the best-known traps of this character are the Sanitas (Fig. 151), the Hydric and Anti-siphon (Fig. 152). The last-named depends for its efficiency on the fluid contents being given a rotary motion in a vertical plane in such manner as to break the siphonic action before the contents of the trap are withdrawn, leaving sufficient water to form a perfect seal. These non-siphoning traps are greatly more economical than vent pipes and otherwise entirely satisfactory; there is no good reason why they should not be more extensively used wherever applicable, especially under sinks and lavatories.

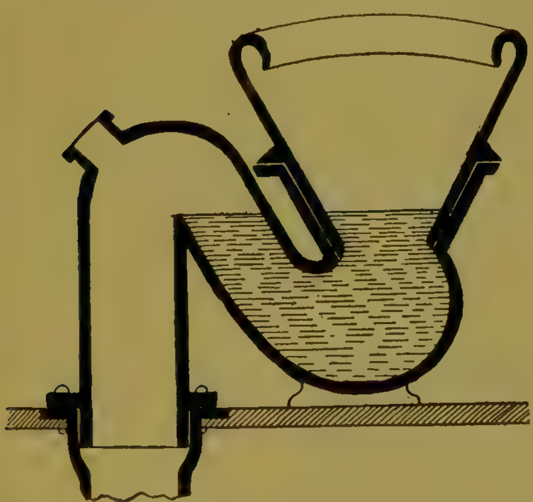


FIG. 153.—Short-hopper closet. (*Munson.*)

WATER-CLOSET FIXTURES.—They should be simple, strong and easily operated, with sufficient flush to wash out the bowl, sweep the excreta beyond the trap and leave enough clean water to fill the trap and bowl to the proper level. The bowl should be so shaped that its sides are not exposed to fouling, and the water of such depth as to cover the discharges.

The specifications of the Quartermaster General's Office provide that the bowls for all water-closets in the Army will be of the best hard-fired

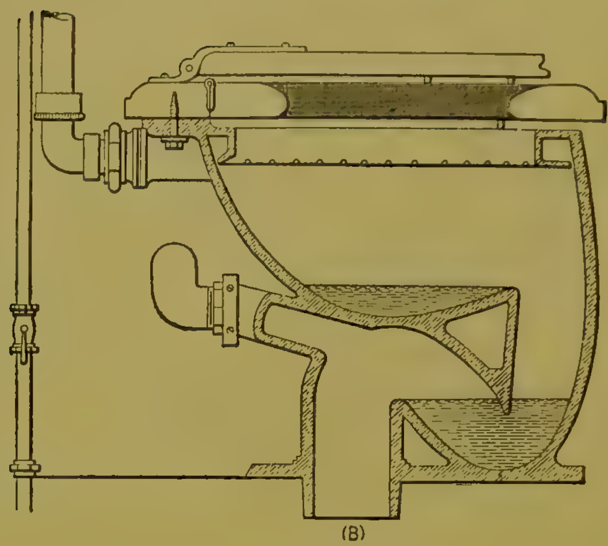


FIG. 154.—Wash-out closet. (Bashore's "outlines of practical sanitation.")

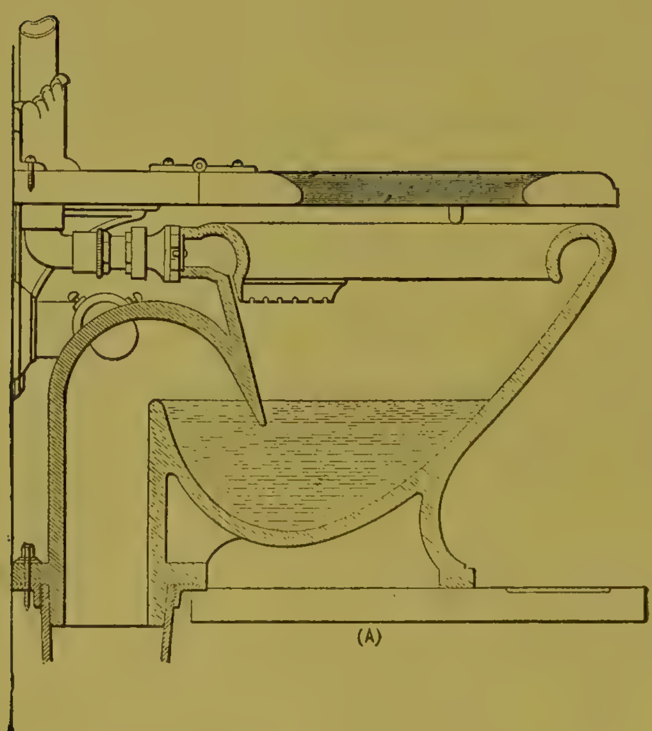


FIG. 155.—Wash-down closet. (*Bashore.*)

sanitary vitreous china, with flawless white glaze, the bowl and trap moulded in one piece; that a fractured piece of the material must not absorb red aniline ink after being immersed in it for one hour; that bowls of all types (except one) are to be oval, with siphon-jet, top supply and heavy roll flushing rim with ample perforations properly distributed; that the connection between each closet and soil pipe will be made with drawn lead pipe 4 inches inside diameter.

Water-closets have undergone a marked evolution during the past quarter of a century, keeping pace with the more liberal water-supply now considered necessary for the needs of communities. The former types, such as the *pan*, *valve* and *plunger closets*, still seen in old buildings and which are operated through a movable internal mechanism, have the merit of consuming little water, but are always foul, malodorous and thoroughly

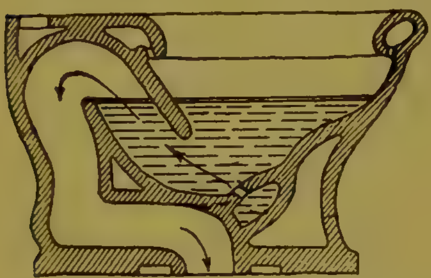


FIG. 156.—Siphon-jet closet with visible jet. Quartermaster's Department type.

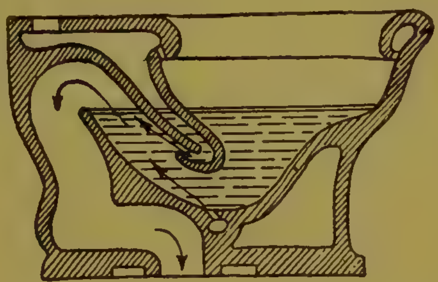
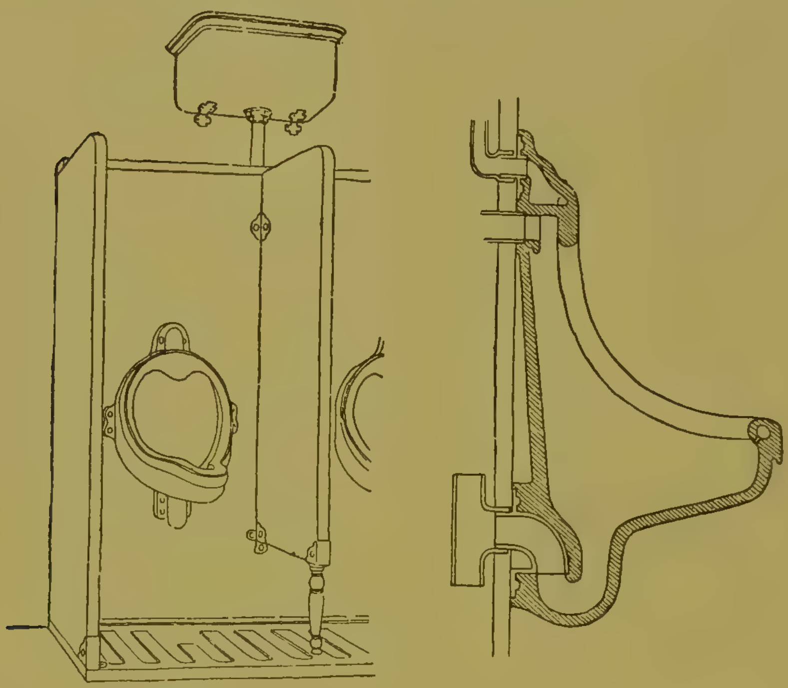


FIG. 157.—Siphon-jet closet with both visible and invisible jets. Quartermaster's Department type.

unsanitary. The *short-hopper closet* (Fig. 153) consisting simply of bowl and trap, with rim flush, is a distinct improvement. In the *wash-out closet* (Fig. 154) the excreta are received in a shallow basin and swept out by the flush into the trap below; they often adhere to the basin, fouling it, as well as the surface against which they are projected, and often partly remain in the trap. This closet, although popular at one time, has but little to recommend it. The so-called *wash-down closet* (Fig. 155) is an excellent development of the *hopper*, in which the bowl forms part of the trap and contains a good depth of water. But the best modern type of water-closet, that which is now generally preferred and most used is the *siphon-jet closet*, of which there are many forms (Fig. 156, 157). The bowl and trap are moulded in one piece, the bowl itself forming the inlet of the trap. The flushing operates in two directions, washing the bowl from the rim, while, at the same time, a separate jet drives the water from the outlet of the trap into the waste pipe; the latter forms the long leg of a siphon which, when filled, sucks out the contents of the bowl, the trap and

basin being then refilled to the proper level by the after-flush. The jet may be visible in the bottom of the bowl (Fig. 156) or invisible under the partition (Fig. 157). The bowl with visible jet is somewhat more efficient and durable but, on the other hand, the hole may become soiled and unsightly or clogged. In the siphon-jet closet the trap vent, in order not to interfere with the action of the siphon, is placed below the long leg of the siphon, generally under the floor.

In order to secure more perfect ventilation in toilet rooms and prevent odors from the water-closet, a vent (Boston or local vent) is sometimes



Outside view. Section through bowl.

FIG. 158.—Urinal for barracks. Quartermaster's Department type.

provided in the upper part of the bowl, just above the water level. Such vent, of course, is entirely independent of the trap vent and cannot take its place.

Modern urinals are constructed of hard vitreous porcelain, with or without bowl. In the latter case, the urine is projected against the walls of the urinal which are constantly washed by running water. The use of bowls is more economical of water. In either case an outlet must be provided at bottom for dripping urine and water used for washing and scrubbing (Fig. 158).

SEWERS.—Sewers are constructed according to the "separate" or "combined" systems. In the former, they receive only the excreta and waste waters of dwellings; in the latter, they carry off not only sewage but also wastes from factories, street washings and rain-water. The separate system has much to recommend it and is often the only one possible in small communities; the volume of sewage is pretty constant and can be readily calculated from the daily water consumption; it is more concentrated and uniform in composition than in the combined system and therefore can be better utilized or disposed of; the sewers being smaller can also be more frequently and effectually flushed. When sewage is to be treated by septic tanks and filter beds, better results are obtained by the separate system, with matters more homogeneous and not too highly diluted. Thus, for instance, whenever a city, in order not to pollute a bay or river, determines to treat its sewage by irrigation or filtration, it will be in the interest of economy, as well as of efficiency, to build large conduits for storm water along the shortest lines directly to the bay or stream, and separate, smaller sewers to convey the excreta and wastes to the disposal plant which may be several miles away. In this separate system, in order to insure a rapid flow and good ventilation, the pipes must not be any larger than necessary; the rule is that a sewer should be at least half-full at the time of greatest flow, and that the velocity of the flow should not be less than two feet per second.

In the combined system the size of the sewers must be such as to accommodate all wastes and rain-water. They may be nearly full or, in the dry season, contain only a small sluggish stream, offering conditions most favorable for the settling of solids and putrefaction of nitrogenous matters. It must be remembered, however, that in large cities, where this system is generally used, the waste waters alone are always sufficient to keep the excreta in a state of very free dilution. When this is not likely to be the case, the smaller sewers should be given an ovoid shape with the smaller end downward.

FINAL DISPOSAL OF SEWAGE.

This is according to the following methods:

1. Discharge into the sea or a lake or river.
2. Chemical treatment.
3. Biological treatment.
4. Local treatment.

Whenever possible, sewage should be thrown into the sea. Such method is entirely satisfactory provided the sewage is carried away and

does not float back. It is often difficult, however, to prevent the pollution of neighboring beaches and shores by returning tides. Great care must be exercised that the sewage be only discharged from such points and at such stages of the tide as will insure its permanent removal. Thus, at Fort Monroe, Va., it was found necessary to collect the sewage into a large tank from which it is pumped out to deep water, twice a day, at the turning point of ebb tide.

Sewage can also be safely discharged into any salt, tide-water stream, so long as the tide and current can be depended on to carry it to the sea. The emptying of sewers into fresh-water lakes or streams is never advisable and should be tolerated only when the latter are not used as sources of water-supply. The excreta of a large city may readily contaminate the waters of a lake for a distance of 1 or 2 miles from the shore. It is a fact that there are now few rivers in the inhabited districts of the United States whose water can be safely consumed without previous purification. This prevalent custom of discharging raw sewage into water-courses, in well-settled communities, is repugnant as well as dangerous, and sanitary engineers are beginning to turn their thoughts to less objectionable methods of disposal. It is highly probable, for instance, that the carriage of the sewage of Chicago to the Illinois River would not be approved at this day. The condition of our rivers would be vastly improved if the sewage should be made to undergo some form of preliminary treatment, so as to be rendered non-putrescible before being discharged into them.

Chemical Treatment consists in the addition of chemicals, whereby more or less of the putrescible substances in solution are precipitated and subsequently separated, together with all matters in suspension. The solids, or "sludge," are removed, subjected to hydraulic pressure and utilized as fertilizer, while the liquids may be discharged into the sea or a stream. The chemicals most used as precipitants are alum, lime and iron sulphate, either alone or in combination. This system is seldom satisfactory and never adapted to garrisons or camps. The sludge is always difficult to dispose of, while the liquid effluent contains much putrescible organic matter and can only be turned into a water-course of many times its volume, and not used as water-supply.

BIOLOGICAL TREATMENT.

Fecal matter, as well as all forms of dead organic matter, animal or vegetable, when left exposed to the air undergo decomposition and disintegration, and eventually become reduced to their primitive elements. This is nature's way to get rid of offensive decaying matter

and to transform complex substances, become useless, into simple bodies which can again be utilized by growing animals and plants. In other words, nature operates a conversion of organic into mineral substances. This is effected through the agency of bacteria and, therefore, is a biological process. This process is the result of oxidation and is often designated as the mineralization or nitrification of organic matter. Oxidizing or nitrifying bacteria are found in great abundance not only in excreta but also in the upper layers of the soil, especially in the first 3 or 4 feet, becoming rare beyond a depth of six feet. This explains why excreta covered in a shallow trench will be much more quickly disintegrated than if deeply buried. These bacteria are non-pathogenic, and broadly divided into aërobic, or those unable to grow without oxygen, and anaërobic, or those which grow best with little or no oxygen. The great majority of them belong to the first division but both kinds take an active part in the decomposition and reduction of organic matter. With free access of air, dead animal and vegetable substances are decomposed by aërobic bacteria without appreciable odor. But as it is seldom that they are penetrated throughout with a sufficiency of air, anaërobic bacteria, which are the micro-organisms of putrefaction. are also brought into action and offensive smells generated.

In the biological treatment of sewage disposal, our aim is to create conditions as favorable as possible to the growth and multiplication of nitrifying organisms. The first step in the process is the conversion of the nitrogenous elements into ammonia (NH_3) by the direct combination of nitrogen with hydrogen. Ammonia by absorbing oxygen becomes oxidized into nitrous acid (HNO_2) which, by further oxidation, is in its turn quickly changed into nitric acid (HNO_3), both acids forming salts by combining with calcium, sodium and potassium. The presence of these alkalies therefore promotes nitrification and renders it more complete. Meanwhile the carbohydrates and fats are also attacked by anaërobic bacteria, but much more slowly decomposed than nitrogenous matters. The outcome of the entire process is the transformation of the putrescible excreta into ammonia and its salts, nitrites and nitrates, carbon dioxid and water. Thus there is rarely as much as 0.01 per cent. of nitrogen as nitrite or nitrate in sewage, while 5 or 6 per cent. may be found in the effluent, after filtration.

The two methods by which the biological treatment is applied are irrigation and filtration.

Irrigation.—In this method the sewage is conveyed upon farm land which has been plowed into hills and furrows and properly drained. The

irrigation is intermittent, that is, suspended for a few hours every day in order that the air may freely penetrate into the soil and promote the multiplication of aërobic bacteria. Thus are fine crops of vegetables grown near Paris and Berlin, and there is no conclusive evidence that, even when consumed raw, they have ever transmitted disease; simple prudence, however, requires that they should be carefully washed before consumption. One acre of land will dispose of the sewage of from 200 to 400 persons by this method.

Filtration.—Before using any system of filtration it is desirable, if not necessary, to apply to the sewage some kind of preparatory treatment. By means of screening and settling tanks much of the coarser matter is removed, while the sludge itself can be materially reduced by the operation of a septic tank.

Septic Tank.—In a septic tank the sewage is placed under conditions which favor the septic process, that is to say, the propagation and action of anaërobic bacteria, with resulting putrefactive decomposition. The sludge is broken up, liquefied and, to some extent, transformed into gases. The carbohydrates and fats are specially attacked in the septic tank. About one-third of the suspended solids and at least one-fourth of the organic matters in solution disappear, while much of the inorganic matter settles to the bottom or forms a scum or mat on the surface. Furthermore, most of the remaining organic particles undergo some disintegrating change which renders them less resistant to the subsequent action of nitrifying organisms in the filter beds. The escaping gases are mostly hydrogen, nitrogen, carbon dioxid, sulphuretted hydrogen, marsh gas and ammonia, some of them highly inflammable and others with offensive odors.

The septic tank is rectangular in shape, five to eight feet deep. After passing through a settling compartment the sewage enters the tank near the bottom so as not to disturb the surface layer nor introduce much air, and flows continuously but very slowly in order to allow the action of bacteria, as well as the rising to the surface or falling to the bottom of the decomposing suspended matters. The capacity of the tank should be at least equal to one-third of the daily amount of sewage to be treated. It is not absolutely necessary to exclude air and light, but desirable that it should be covered so as to exclude rain and prevent smells. A septic tank can be operated several years without any great accumulation of scum or sediment. The fact of its being chiefly concerned in the decomposition of carbohydrates renders it specially adapted to the treatment of domestic sewage.

The effluent from the septic tank still contains more than half of the organic matter of the sewage and remains highly putrescible. It is therefore necessary to submit it to the action of aërobic bacteria by filtration. This is best effected by either sand filters, contact filters or sprinkling filters.

Sand Filtration.—In this method the sewage is concentrated over small areas of specially chosen and prepared ground, with porous, thoroughly underdrained soil. The filter is generally divided into four equal parts, each in turn receiving sewage during 6 hours and remaining unused during 18 hours to insure the aëration of the bed and the multiplication of bacteria. Sand filtration, largely used in America, is the most satisfactory and economical method of sewage disposal where the nature of the soil permits its use; it generally yields a clear, non-putrescible effluent which may be turned into any stream. One acre of sand filter will dispose of the sewage of 1000 people.

Contact Filter.—This filter consists of a water-tight compartment, generally of concrete, filled with coarse material such as coke, clinker or broken stone with relatively large interspaces. The sewage is applied at regular intervals, left in contact with the bed for a few hours and then slowly drained out. After each application the bed is allowed a short rest. Contact beds are generally disposed in 2 or 3 sets, the second set containing smaller filtering material than the first, and the third than the second, the effluent passing automatically from one set to the next. One acre of contact beds will treat the sewage of 5000 people.

Sprinkling Filter.—This filter, also called "trickling" or "continuous" filter, represents the most important advance of the last few years in the treatment of sewage. It consists of the same compartment and material as the contact filter, but is operated differently. Instead of the fill and draw, or intermittent, principle, the sewage is applied continuously either as a spray or in very thin sheets sprinkled over the surface, then trickles down and passes out through the underdrains which are comparatively large in order to insure thorough aëration of the entire bed. The more subdivided and broken up the sewage, the greater the oxidation and the better the result. The sprinklers may rotate on an axis, in which case circular beds are used, as in England, or they may be fixed, in rectangular beds, as in this country. Sprinkling filters may run 10 to 15 years before the material becomes clogged and requires renewal. They yield a higher degree of purification than contact filters and their rate of treatment is about 4 times as great, one acre of sprinkling beds being able to dispose of the sewage of 20,000 people. The effluent is not quite as good as that

obtained from intermittent sand filtration, and is more or less turbid, but it is well nitrified, non-putrescible, stable and fit to be discharged into almost any stream.

Combined Method.—The ideal method of sewage disposal, such as is used at Lawrence, Mass., consists in the septic tank treatment followed by sprinkling beds and sand filtration. The effluent thus obtained is practically pure and may be safely allowed to run into any water-supply.

DISPOSAL IN GARRISON AND CAMP.

The disposal of human excreta is one of the most important problems that confront the military hygienist, one that should be the object of the constant solicitude of the medical officer and require his most careful attention. All our military posts, with few exceptions, are provided with modern water-closets and sewerage, and their excreta and wastes, after or without previous treatment, carried away to the sea, neighboring lakes or streams. Other systems more or less applicable to permanent stations are described under *Camps*. The use of the primitive privy-pit at a post, cantonment or permanent camp could only be justified by very exceptional conditions.

The method adopted for some of our largest interior posts is in conformity with the highest modern standards, except that contact beds are used instead of the more expensive sprinkling filters. The sewage plant at Fort Benjamin Harrison, Ind. (Fig. 159) has a maximum capacity of 200,000 gallons in 24 hours. It does not receive surface or storm water. The degree of purification required by the Quartermaster's Department is that all solid matters will be arrested, and 80 per cent. destroyed; that the effluent shall not contain more than 1.50 parts of albuminoid ammonia in 1,000,000 parts, and that 1,000,000 parts shall consume less than 15 parts of oxygen in 4 hours; that the effluent shall be clear, colorless, odorless, non-putrescible, and free from typhoid and other pathogenic germs.

The plant consists of 5 tanks, two sets of contact beds and one sand filter, all built of concrete and lined with a coat of cement plastering 1/2 inch thick. The tanks are a grit tank or sediment chamber, three septic tanks and a dosing tank, all covered over, with roof properly ventilated and a sufficient number of manholes. The grit chamber receives the raw sewage and retains all heavy insoluble matter; it has submerged openings, guarded with slide gates, one into each septic tank, and a drain-pipe connected with the by-pass drain. The three septic tanks are each of sufficient

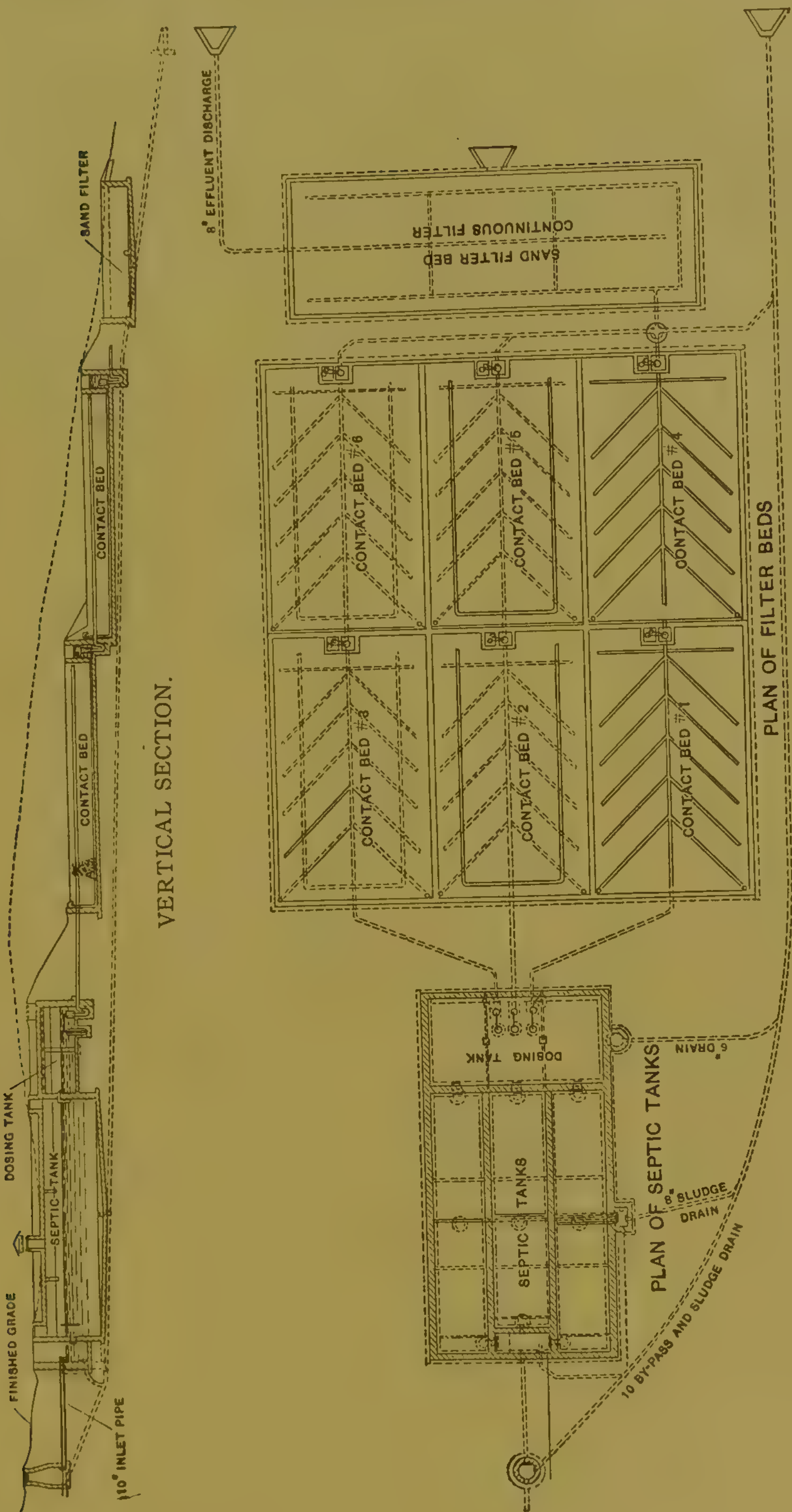


FIG. 159.—Sewage purification plant. Fort Benjamin Harrison, Indiana.

size to give treatment to 67,000 gallons of sewage in 24 hours. A baffle wall, in each tank, serves to scatter the sewage as it enters from the grit chamber. From the septic tanks the effluent is discharged into the dosing tank by a submerged weir so placed as not to disturb the mat or scum formed on the surface. Each tank is provided with a drain so that the sludge may be removed into the by-pass drain without disturbing the surface mat. The dosing tank collects the effluent until it has enough to charge one contact bed, and then discharges it onto the bed by an automatic alternating device.

Each set of contact beds consists of three beds, each bed of such capacity that the time consumed between doses, that is to say, in filling, resting full, emptying and aërating, shall be no less than 6 nor more than 8 hours.

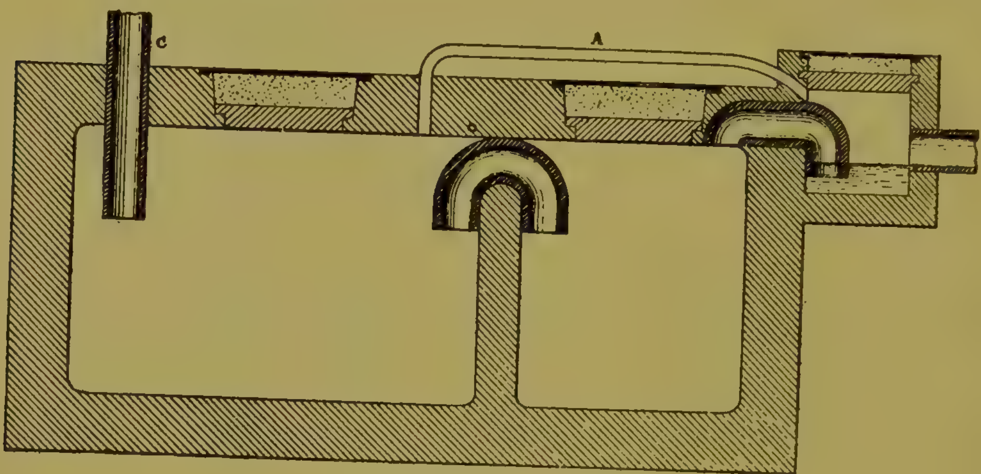


FIG. 160.—Mouras vault.

The effluent is distributed over the surface of the beds by open-joint vitrified pipes, and collected at the bottom by horseshoe-tile pipes, being discharged from the beds of the first set to those of the second by an automatic-timed device, and finally upon the sand filter.

The filling material of the beds, 4 feet deep, is of good, hard, broken stones or pebbles, capable of resisting the alternate action of water, air and frost without dissolving or disintegrating. In size it ranges from 1 to 2 inches in diameter at the bottom; decreasing to 1/2 inch at top in the first set, and to 1/8 inch in the second set.

LOCAL OR DOMESTIC TREATMENT.

In the absence of a general or central system of sewerage, various methods may be resorted to for the disposal of excreta and wastes. Ordinary

vaults are still used in many communities although rarely at military posts. They should be lined with stone or brick and cemented so as to be water-tight and not endanger neighboring water-supplies. The water-closets may empty directly into them, or else by means of soil pipes and drains. Inasmuch as these vaults have to be periodically emptied, it is evident that they are only a poor makeshift and not a final means of disposal.

An improvement upon the ordinary vault is the *Mouras Vault* used with various degrees of success in many countries. In this system a notable amount of septic decomposition takes place, perhaps also a certain degree of nitrification, so that the overflow may be allowed to run into a large stream or upon a field for irrigation purposes. As seen in Fig. 160, this vault consists of two unequal compartments connected by means of a siphon; the soil-pipe C dips in the liquid contents of the larger compartment; as these contents rise they pass through the siphon into the smaller compartment and thence through another siphon into the outlet.

Whenever a satisfactory system of sewerage is impracticable at a post or cantonment, for instance where the weather is too cold for water-closets, one of the methods of disposal described under *Camps* may be used, especially the earth-closet, milk-of-lime closet or, still better, one of the incinerators.

DISPOSAL OF GARBAGE.

Garbage and all waste material, to be properly disposed of, at posts as well as in cities, must be sorted and divided according to their composition. Kitchen wastes, for instance, which contain a large proportion of putrescible and dangerous organic matter, should be separated from dry refuse and ashes. At least two cans are required, but three are still better, one for kitchen and liquid wastes, a second for ashes and other dry non-combustible matter, and a third for combustible refuse. The receptacles should be of galvanized iron, air-tight and fitted with lids to exclude flies and prevent odors. In cities, at least three-fourths of the dry refuse has a salable value. From the kitchen garbage a notable proportion of oil can be obtained, while the residue is utilized as fuel. At military posts, such economic disposal is impracticable. The rule has been, in the absence of crematories, to feed the kitchen garbage to pigs or pour it into pits, and to throw all other refuse and wastes on the dump. The latter is incinerated so far as it is practicable, generally very imperfectly.

Such primitive method should no longer be countenanced at any of our garrisons or camps. The only proper way to dispose of garbage and all

other combustible refuse is by fire, and it is always possible, in all places, to improvise an efficient "rock pile crematory" (see page 405). Most of our large posts are now supplied with regular grate crematories. These are of various kinds. It is generally stipulated that they shall be of a capacity of not less than two tons per hour, or sixteen tons per day of eight hours, and so constructed as to consume manure, garbage and liquids; in other words, all wastes. It is especially necessary to fire empty tin cans; they always contain organic matter adhering to their walls and are favorable media for the multiplication of all sorts of bacteria until thoroughly burned out.

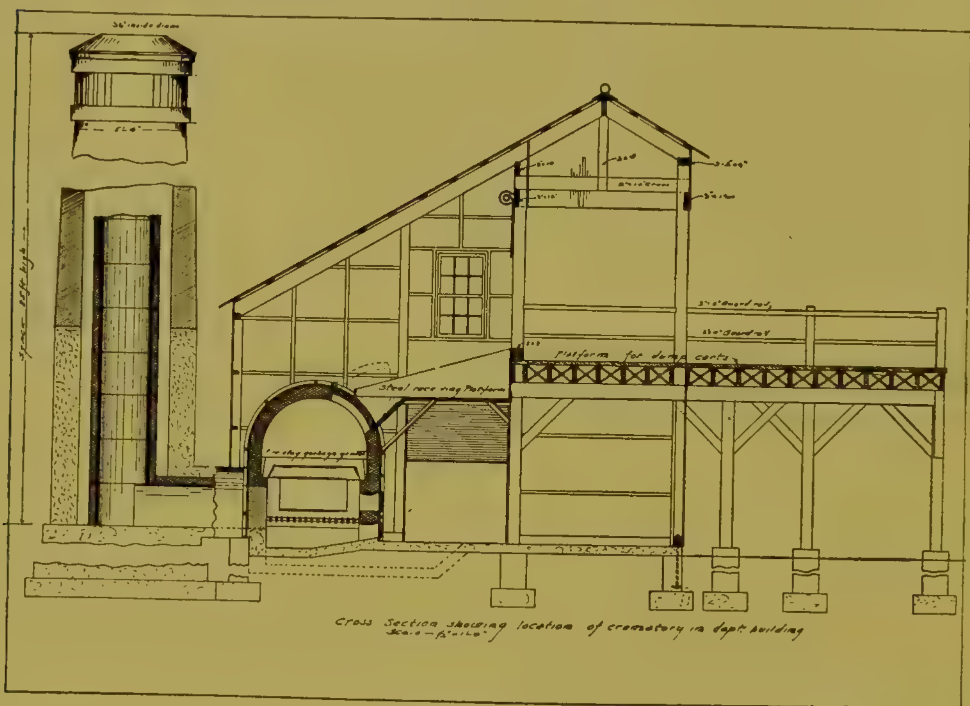


FIG. 161.—Crematory building—Fort D. A. Russell, Wyo.

One of the latest and best types of crematories is illustrated in Figs. 161 and 162. The building is of wood, covered on sides and roof with corrugated sheet steel, and resting on brick or stone walls and piers with concrete footings; the floor is of concrete. The doors, of corrugated sheet steel, are of the rolling pattern. When this building is erected upon a side-hill the runway and platform are omitted, but a longitudinal stone retaining wall is necessary. The apparatus (Fig. 162) consists essentially of a fire-clay garbage platform above, and of five cast-iron fire grates below, namely, two on each side for incineration and a central one to strengthen the draft and complete the combustion of gases. The garbage being

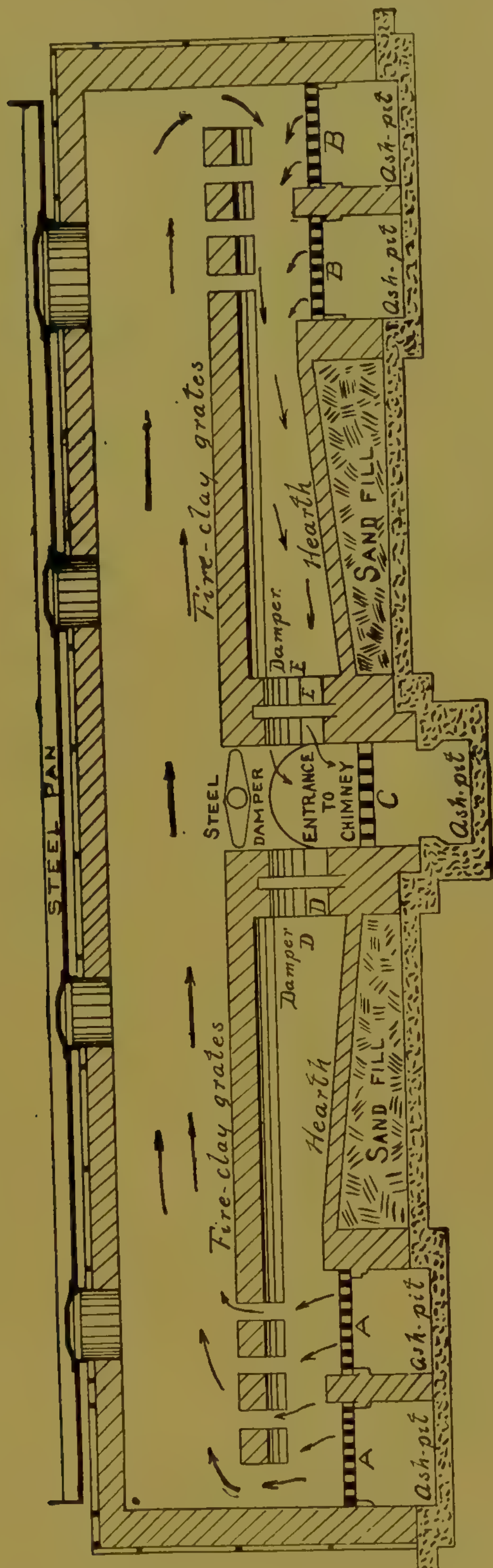


FIG. 162.—Crematory grates.—Fort D. A. Russell, Wyo.

spread upon the platform, fires are started in the grates A A and C, and the damper D closed. The heat and smoke current passes through and over the garbage and then under the platform on its way to the smokestack. The garbage, being sufficiently dried on the left half of the platform, is thrown upon the grates A A to serve as fuel. When the garbage on that end of the platform has been disposed of, the damper D is opened and damper E closed, and fires started in the grates B B, thus reversing the heat current and repeating the same process on the right end of the platform; fresh sewage being dumped on meanwhile so as to keep the platform always supplied.

CHAPTER XXXI.

SOIL.

Soil is a mixture of mineral substances, chiefly sand, clay and limestone, with more or less organic matter. Its principal mineral constituents are: silica (quartz, sand, sandstone, etc.) which forms more than half of the earth's crust; aluminum, mostly as clay (silicate of aluminum); lime as carbonate (limestone), phosphate and sulphate; and magnesia as carbonate and sulphate. Other constant but secondary constituents are: iron and manganese, the former playing a very important part in the growth of plants; chlorine as chloride of sodium and potassium; sulphur as sulphides and sulphates; phosphorus as phosphates.

The vegetable mould generally present in the soil and forming the bulk of its organic matter, is called *humus*, a very complex substance particularly rich in nitrogen and therefore characteristic of fertile land. Peat and muck result from the incomplete decay of vegetable matter under water, the former being more compact and fibrous than the latter. Nitrogen exists in the organic matter not yet decomposed, as well as in the products of its decomposition, namely ammonia and its salts, nitrites and nitrates.

PHYSICAL PROPERTIES OF SOILS.

All soils are porous to air. This porosity does not depend so much upon the size of the individual particles of earth as upon their shape and arrangement. The total volume of the interstices or pores between the grains, amounts to about 35 per cent. of the entire mass in ordinary soils; even the most compact rocks have more or less porosity although impervious to water. The permeability of soils to air is not necessarily proportional to their porosity, but depends chiefly upon the size of the pores; as these grow larger, permeability increases, although the volume of porosity tends to decrease; thus the permeability of medium gravel is more than 100 times greater than that of medium sand although its total porosity is less. Clay, consisting of exceedingly fine adhesive particles, possesses but little permeability, unless fissured or crumbly or mixed with sand or chalk. The degree of permeability of any soil to air is greatly influenced

by the amount of contained moisture; water drives out the air and may render the soil, especially if largely composed of clay or peat, completely impervious to it.

Ground Air.—Ground air differs from atmospheric air in its much greater proportion of carbon dioxid; it is also somewhat richer in ammonia and occasionally contains sulphuretted and carburetted hydrogen. All these gases result from the oxidation of the organic matter in the soil where, therefore, the air suffers a corresponding loss of oxygen. The amount of carbon dioxid varies much according to the nature of the ground and the depth from the surface. A soil rich in organic matter evolves a great deal more of it than if mainly composed of sand or chalk; likewise, more is generated in summer, when decomposition is active, than in cold weather. At a depth of one meter the amount of carbon dioxid is seldom less than 5 parts per 1000 of air and may reach 15 or 20 parts, while at a depth of 4 meters it is two or three times as much. Ground air is not immobilized in the soil; on the contrary, owing to differences of temperature between it and the atmospheric air, winds, rise and fall of subsoil water, etc., it is always in motion, constantly displaced, renewed and mixed with outside air, so that the atmospheric layers nearest the ground are always more or less contaminated with it. The teaching of Pettenkofer that the amount of carbon dioxid in any part of the soil is an index of the amount of organic matter present is obviously erroneous, since, on account of the permeability and ventilation of the soil, the gas found in one place may easily have been generated at some other place.

Ground Moisture.—Water is retained in the ground by two forces: molecular adhesion, that is, the attraction of the surfaces of soil grains for liquids, and capillary attraction. The latter force is active only when the pores or interstices are sufficiently small (less than a millimeter). This capillary water forms the great bulk of the retained moisture; it is the more abundant that the texture of the ground is closer and more compact; thus a soil with grains half a millimeter in diameter will hold nearly three times as much water as one with grains 2 mm. in diameter. Sand, with its relatively large pores, absorbs but little water, chalk absorbs a good deal more, while clay retains from 70 to 80 per cent. of its weight. Organic matter is very absorbent of water, humus being capable of retaining several times its weight of it. Permeability of the ground to water, as to air, depends upon the size of the pores, and therefore is generally inversely proportional to capillarity or the capacity of water retention. Thus sand is freely permeable, that is, permits a rapid percolation of water; chalk is less so, while clay may be totally impermeable. Even marls (mixtures of

chalk and clay) not containing more than 40 or 50 per cent. of clay, are sometimes quite impervious. Rocks vary greatly in this respect, those of volcanic origin being absolutely impervious, while sandstones and limestones are quite porous and generally allow more or less filtration.

Rain-water percolates through the soil and subsoil until it reaches an impermeable stratum, either clay or rock, upon which it collects to a variable depth. This ground water furnishes more or less moisture to the subsoil through capillary attraction and much of it is evaporated through the soil. It is in constant motion, the direction of the flow depending necessarily upon the slope of the impermeable stratum below, but this slope cannot always be inferred from that of the soil surface. The trend of this ground water may generally be assumed to be toward the nearest water-course below it, but often the only way to ascertain it, as well as the depth of the water level, will be by the digging of a series of wells. The rise and fall of the ground water depends chiefly upon the rainfall, but it is materially influenced by the extent of vegetation, especially woodlands, the rate of evaporation, and the amount drawn for the supply of neighboring communities.

Ground Temperature.—The soil being a bad conductor of heat, changes in the temperature of the air are less and more slowly felt a few feet, or even a few inches, beneath its surface; thus a cave, cellar or dugout is cooler in summer and warmer in winter than the outside air. The power of the soil to absorb solar heat depends mostly upon color, black absorbing much more than lighter shades, and white sand least. The power of emission or radiation is proportional to that of absorption, thus dark soil loses more heat at night than chalk or sand. Snow, being also a poor heat conductor, protects winter crops from extreme cold. A hole dug in a snow drift, or shelter built of snow, may save soldiers or travelers from death by congelation. The specific heat of water being about four times that of air and of most mineral substances, it follows that water is not so readily affected by heat and maintains a much more equable temperature than air or soil; moist soil, therefore, absorbs heat more slowly than dry soil and its temperature does not rise to the same degree. For instance, the heat that would raise the temperature of sand 6.67° F., and of weathered granite 3.33°, will only raise that of water one degree. It is chiefly by its evaporation, however, that moisture lowers the ground temperature, for this evaporation is always at the expense of the heat of contiguous solid substances.

Influence of Vegetation on Soil.—Plants, but especially trees whose enormous system of roots extends many yards in all directions, absorb

large amounts of moisture and tend to dry a damp soil; hence the wisdom of planting quick-growing trees with abundant foliage in marshy lands. On the other hand, woodlands have a marked effect in retaining rain-water and regulating its penetration of the soil. The leaves become so many receptacles from which the raindrops, forming tiny streamlets, flow down the stalks and branches to the trunk, and continue to reach the ground long after the rain has ceased, thus preventing any sudden flooding. But the water is also entangled and arrested by the compost of vegetable matter, together with the litter of foliage and twigs which cover the forest soil, and therefore more of it penetrates the soil and is utilized. It has not been proved that the removal of forests materially decreases the rainfall in any region, but it is certain that it brings about the loss of a large proportion of it; the water, not being arrested by the foliage nor retained by the soil compost or litter, rushes off into the nearest water-courses, causing sudden freshets and destructive torrents. Vegetation tends to equalize the temperature of the soil, absorbing less heat during the day and retaining more during the night. "Herbage acts as a protection against excessive heating in hot climates, and as a blanket to prevent loss of heat in cold ones" (Harrington).

POLLUTION AND SOIL BACTERIA.

The soil is the great receptacle in which all the organic filth not directly carried to the ocean is deposited, and therefore would soon become hopelessly polluted were it not for the provisions made by nature to maintain a safe equilibrium between dead organic matter and living animals and plants. Nature's scavengers are the micro-organisms or bacteria of the soil. The ground is full of them, from several thousands to several millions per cubic centimeter. As they feed and multiply on organic matter, the more there is of it, that is the richer is the soil, the more abundant they are. Other favorable conditions to their growth are a certain degree of heat and some moisture. These bacteria, as already stated, are found mostly in the upper layers, especially in the first 4 feet, below which they diminish rapidly so that few are found beyond a depth of 10 or 12 feet. These soil microbes consist mainly of beneficent aërobic saprophytes. Their chief and most important function is the decomposition of all dead organic matter, animal and vegetable, and its transformation into simple, assimilable elements which are again available for growing animals and plants. Another useful office which they perform, through their competition and greater power of resistance, is the prevention of

the growth and multiplication of pathogenic bacteria. The latter are more delicate organisms; only two are commonly found in the earth and able to perpetuate themselves, the bacilli of tetanus and of malignant edema; the others are generally incapable of enduring long the unfavorable conditions of the soil and the antagonism of the saprophytes. Thus Klein found that very few of the bacteria of cholera, typhoid fever, diphtheria, plague and tuberculosis are found in the bodies of animals, dead from these diseases, a month after their burial. It has been observed that pathogenic bacteria are very quickly destroyed in peaty soils, doubtless on account of the organic acids which the latter contain.

With plenty of air the aërobic saprophytes cause the prompt decomposition of organic matter with little or no offensive odor; but in compact, wet or impermeable soil, anaërobic bacteria, the organisms of putrefaction, come into play and ill-smelling gases are evolved. This, however, is mitigated or entirely neutralized by the remarkable absorbent power of earth for gases and vapors, the gaseous atoms penetrating into the intra-molecular spaces of the soil elements and condensing therein. This power varies according to the composition of soils; sand has but a feeble attraction for gases, while humus or any soil rich in organic matter, if not too wet, is very absorbent. This affinity is particularly marked for odorous gases; thus it has been observed that ordinary illuminating gas, in passing through a layer of earth, may lose its characteristic odor but not its poisonous constituents which thus become the more dangerous that their presence is unrevealed to the sense of smell.

CHAPTER XXXII.

CAMPS.

Camps vary greatly in their composition, size, form, location and purpose, and, although the principles underlying their sanitation are always the same, the sanitary measures called for will vary correspondingly. There are the summer camps of peace time for field instruction and maneuvers, with many of the comforts of garrison life; camps of mobilization, at the beginning of war, where troops are mustered and organized, after being stripped of superfluities, and the camps of actual warfare, necessarily reduced to the indispensable. In presence of the enemy, before or after a battle, while marching and maneuvering for position, the troops may have to camp many nights on ground which is objectionable from the sanitary point of view. They remain in deployed formation and will generally bivouac on or near the positions they occupy. In this formation they are drawn out into a thin line and therefore not exposed to the dangers attendant upon crowding. Bivouacs, especially if shelter-tents are not available or cannot be put up, and the weather is inclement, expose the troops to severe and mostly unavoidable hardships. When a choice is possible, the principles which guide in the selection of camp sites will apply to the selection of places for bivouacs. Every shelter should be utilized. Light woods are always desirable on account of the shelter, fuel and material they afford. When troops are likely to remain days and weeks along the line of fire, confronting the enemy, they should make themselves as comfortable as conditions permit, in trenches and dugouts, or in tents, and carefully observe all sanitary measures applicable to their situation.

Selection of Site.—When there are no tactical questions involved and the camp is to be occupied for some time, sanitary considerations should prevail and great responsibility will rest upon the medical officers concerned in the recommendation of a suitable site.

When in the enemy's territory, careful information must be obtained from the inhabitants regarding the prevailing diseases of man and animals in the zone to be occupied, especially in the proximity of the camp grounds, as well as the quality of the water-supply and the character of the food to be procured from local sources.

The grounds should be large enough to accommodate the command without crowding. The spread of infectious diseases in camp is always to be apprehended, being favored by the concentration of large numbers of men, most of them at a very susceptible age, under hygienic conditions seldom entirely satisfactory. To guard against it, individual men must be given as much space as possible within their respective organizations, and the organizations placed as far apart as topographical conditions and military exigencies permit. A brigade of 4000 or 5000 men is as large a command as should be placed in one camp. The site should be high enough to secure dry soil and good natural drainage; the summit of a low ridge with gentle slopes, a high plateau with slight declivity, or the high bank of a river, are very desirable. It is quite important that the location of a camp be such that its drainage shall not pollute the grounds of the camp next below it; if such location cannot be avoided, a large ditch should be dug between them. In cold weather, a slope to the south, with woods to break the force of the wind is an advantage. In hot weather, high grounds, swept by the breeze and, if possible, shaded by trees, should be preferred. Grounds near the foot of a hill are exposed to flooding in rainy weather and remain muddy and wet long afterward; unless protected by a deep ravine, they should be avoided.

The vicinity of marshes and stagnant waters is objectionable on account of the annoyance and danger of mosquitos; it is also undesirable on account of the damp atmosphere and possible air pollution from sulphuretted hydrogen, marsh-gas, ammonia and other products of organic decomposition. Although marsh water may be very foul, the vapor rising from it by evaporation is always entirely free from micro-organisms and therefore incapable of conveying any infectious disease.

An old camp site should not again be used by a command until sufficient time has elapsed for the disinfecting action of the air, sun and rain; this period of time will vary according to the extent of the pollution, especially of the amount of fecal matter left in the soil or subsoil. As a rule, in dry weather, a period of 2 or 3 months will remove all danger of soil infection.

A camp site must be dry. A humid atmosphere makes the heat more oppressive and the cold more penetrating. Moisture renders the soil cold and chilly, depresses the body vitality and reduces resistance to disease, predisposing to rheumatism, neuralgia, diarrhea, tuberculosis and malarial fever. The degree of dryness of a site can be estimated from the general topography of the surrounding country, its elevation above the nearest ponds and streams, the character of the vegetation and, more surely, from the depth of the ground water as determined by digging.

The ground water, as a rule, should not be nearer than 10 or 12 feet, but a depth of 6 to 8 feet is compatible with a dry surface when the drainage is good and the subsoil porous.

Soil.—The soil and subsoil of a camp must be porous and permeable, that is, allow rain-water to sink readily through them. Gravel and sand are excellent for the purpose. Loams (mixtures of sand, clay and organic matter), although not so good are generally satisfactory. The most unhealthful constituent of the soil is clay, for although it absorbs and holds much moisture it is totally impermeable; whether forming the soil or subsoil it retains the surface water which only partially disappears by slow evaporation. Chalk, limestone and sandstone are porous and healthful, but chalk mixed with clay in about equal proportion (marl) becomes impermeable. Volcanic rocks, such as granite, trap, gneiss, etc., except when seamed and fissured, are impervious; but as they absorb little water and dry quickly they make excellent sites, provided there is enough slope for good drainage.

As already stated under *Soil*, sand allows water to pass through it while retaining very little of it. If white or light colored, it does not absorb much heat during the day and loses but little at night; in other words, the power of heat absorption and radiation of white surfaces is small. As a rule, sand does not contain much organic matter and therefore does not favor the development of pathogenic microbes. These are all good reasons for preferring sand as camp soil; but, if nearly pure, it is likely to be soft, yielding and heavy to the foot of man and beast; while, if white, the glare of its surface is trying to the eye; it is best that it should be mixed with a certain proportion of gravel to give it consistency and firmness as well as a neutral color.

Vegetation.—Vegetation on a camp site is highly desirable, but thick undergrowth which excludes the sun and keeps the ground moist must be cleared out. Trees and shrubs should be saved as far as possible so long as they do not seriously interfere with drills and formations. They afford protection from sun and wind and modify the extremes of temperature, cooling the summer heat and tempering the winter cold. Grass is most useful on camp grounds and should be preserved and protected. It mitigates the heating of the soil by day and its chilling by night; does not reflect light and heat, prevents mud and dust, as well as the washing and gutting of the soil by rain.

The effect of vegetation upon mosquitos and other insects is variable. It has no special attraction for them nor, in the absence of stagnant water, does it afford them breeding places, for it is a well-known fact that mos-

quito eggs are only laid in water. But vegetation affords them shelter during their flights in search of water, or when blown by the breeze, and may thus retain them in the vicinity of habitations. Therefore, in a malarial country it is well, in camps and near dwellings, to have the trees thinned out, no undergrowth, and the grass closely cut. On the other hand, a screen of wood between mosquito-breeding waters and the camp grounds will stop many of these insects and be distinctly advantageous.

Poisonous Plants.—There are but few poisonous plants in this country likely to annoy soldiers in camp or on the march; the following are the only species worth mentioning, all belonging to the genus *Rhus* or Sumach: *Rhus toxicodendron* (Poison Ivy or Poison Oak), found from Canada to Mexico and west to Arizona, Oregon and British Columbia, under various forms ranging from a small upright shrub to a high thrifty climber; easily recognized by its trifoliate leaves and ovate pointed leaflets, one of the very few shrubs or climbers with 3 leaflets. In California it is replaced by *Rhus diversiloba* which differs only by the obtuse or rounded apex of the leaflets. Both species are very poisonous to susceptible people and should, so far as practicable, be eradicated from camp grounds. *Rhus venenata* or Poison Sumach, of the wooded swamps of the Eastern and Middle States, a large upright shrub or small tree, although likewise very toxic, is not common enough to be much of a menace to our camps. The poison oak of the West Indies (*Comocladia dentata*) is a slender upright shrub bearing a whorl of shiny, pinnate, toothed leaves near the top; it is closely allied to *Rhus* and, under the name of Guao, has been a great nuisance to our soldiers in Cuba.

The location of a camp will be especially determined by the water-supply which should be abundant, of good quality and conveniently accessible. Grass or hay, as well as wood, are also essential, but can be brought from any distance.

TENTS.

Troops in camps are usually under canvas. Tents give shelter against sun and rain and, to some extent, against cold, but do not afford the protection and comfort derived from ordinary buildings; for hospital and other special purposes they should be resorted to only when suitable buildings are not available. Flies, or outer covers, add much to their comfort and must always be used when on hand, being adjusted so as to leave an air space between them and the tent roofs. This space is important, but need not be so great in cold as in hot weather; the air thus en-

closed being a bad heat conductor excludes the sun's heat in summer and prevents loss of interior heat in winter.

Tents are an excellent shelter against nocturnal radiation but, even with flies, afford an imperfect protection against heat and cold, their temperature during the day differing but little from that of the external shaded air, so that they are easily affected by weather changes. Their

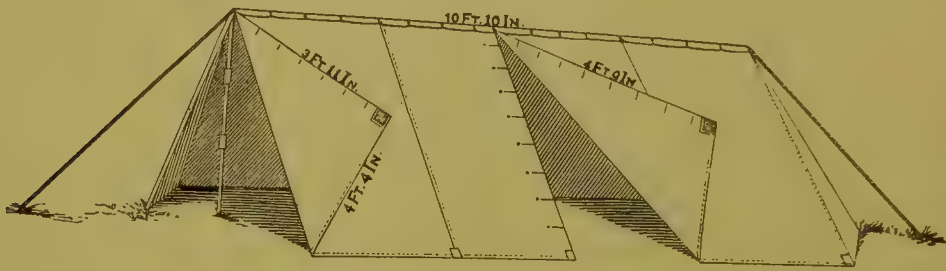


FIG. 163.—Double shelter tent.

ventilation is generally satisfactory in summer when the walls can be lifted and the doors left open; it is aided by the free exchange of gases taking place through the canvas in all seasons. But in winter, when it is necessary to pin down the walls and close the openings, the ventilation is often imperfect, although, on account of the porous walls, seldom very bad. In rainy weather, however, when the pores are closed by the con-

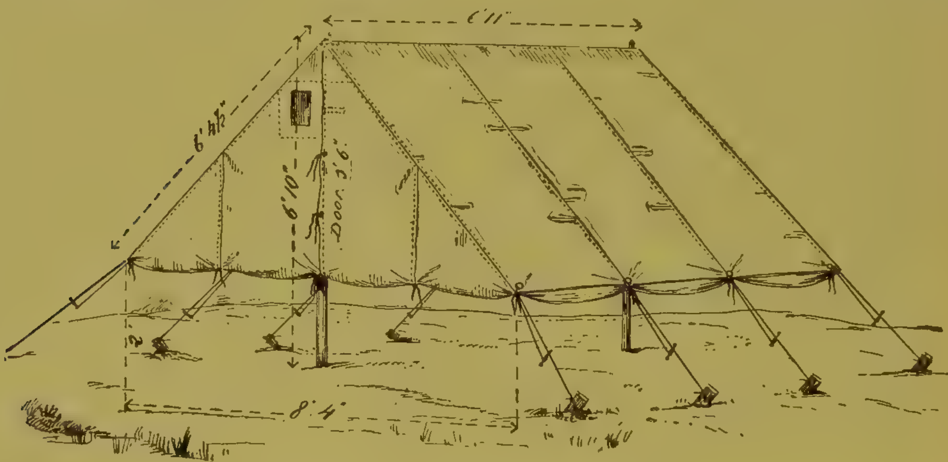


FIG. 164.—Common tent. (*Munson.*)

tracting canvas, the air may become quite foul if other means of aëration cannot be used.

In cold weather, tents are made much more comfortable by lining the walls with blankets or thick flannel; even paper is useful for the purpose. Except on very cold days this expedient will prove a good substitute for a stove, especially where fuel is scant.

The tents used for the shelter of troops in our service are of various sizes and forms, and designated as shelter tent, common tent, wall tent, conical tent and hospital tent.

Shelter Tent.—Each man on the march carries, as part of his equipment, one-half of a shelter tent; it serves as the wrapper of his blanket-roll. This shelter-tent half consists of a rectangular body 65 inches long and 61 inches wide, and a triangular flap 57 inches from ridge to base and 52 inches along the base (Fig. 102). Two tent halves buttoned together

FIG. 165.—Wall tent, regulation, with fly.

at the ridge form a complete tent. It is pitched on two 3-jointed poles 47 inches long and occupies a space 64 inches long and 76 inches wide. The two triangular parts when pinned to the ground enclose an additional ground space 20 inches deep. A double shelter tent is formed by buttoning together the square ends of two single tents, two complete tents being used except one pole, with two guy ropes at each end (Fig. 163). Such double tent, being closed at both ends, affords much better protection to its four occupants than does the single tent (open at one end) to its two occupants. The shelter-tent half is provided with permanently attached straps to secure the roll when wrapped around the clothing. With pole and pins it weighs 9 pounds and 9 ounces.

Common Tent.—The common tent (or A-tent) is the next larger size and intended to accommodate 3 men (Fig. 164). It is 6 feet 10 inches high, 6 feet 11 inches long and 8 feet 4 inches wide, with wall 2 feet high. It has a ventilating opening, 3 x 6 inches, in front and rear, with inside flap to close it when necessary. The canvas weighs 26 pounds, and the tent complete, including poles and pins, 50 pounds.

Wall Tent.—Wall tents are generally intended for the accommodation of officers. Two types are provided, the regulation wall tent (Fig. 165) for temperate and cold climates, and the tropical wall tent (Fig. 166).

FIG 166.—Wall tent, tropical, with fly.

The regulation or ordinary wall tent (model 1907) is 8 feet 6 inches high, 9 feet 2 inches long, 8 feet 11 inches wide, with wall 3 feet 9 inches high. It has, in front and rear, a round "ventilator and stovepipe opening," to serve as a ventilator in summer and stovepipe hole in winter, with inside flap to close it when necessary. The tent and fly weigh 58 pounds; with poles and pins the total weight is 98 pounds.

The tropical wall tent (model 1907) has the same dimensions as the preceding, but the sides of the roof, one foot from the apex, are drawn in, the whole length of the tent, by a horizontal band of canvas, one foot wide, which forms the floor of an attic or "pocket." This floor is perforated by

6 holes, each 6 inches in diameter, for ventilation, and by 2 smaller holes (one at each end) for the upright poles to go through. Each end of the pocket can be closed by a flap in inclement weather. Besides the ventilation produced by the holes in the floor of the attic, the drawing in of the

FIG. 167.—Conical wall tent, regulation, showing interior.

sides of the roof separates it from the fly and increases the layer of air between them.

Conical Tent.—Two types are provided, the regulation conical tent and the improved conical tent.

FIG. 168.—Conical wall tent, regulation, showing exterior.

The regulation conical tent (model 1904) is a round tent with conical roof, supported by one upright pole (Fig. 167). It is 16 1/2 feet in diameter and 10 feet high including the wall which is 3 feet high. The truncated top of the roof forms an opening 18 inches in diameter. This opening is

firmly stitched and reinforced over an iron ring and supported by 6 chains which hang from a plate passed over the spindle of the pole. It is closed by a hood with hole in its apex for the spindle of the pole. This hood can be opened at the side to any extent for ventilation or for the exit of smoke, and shifted around as the wind may require, by means of 5 lines fastened around the bottom (Fig. 168). The door of the tent is 7 feet high, made of two equal pieces of canvas which lap and form double thickness when closed. The pole rests upon a strong iron folding tripod. From the head or socket of the tripod depends a chain with hook to hang cooking utensils.

The tent and hood weigh 76 pounds; with pole, tripod and pins its total weight is 128 pounds. It can be heated by the regulation conical stove and stovepipe or, when necessary, by open fire.

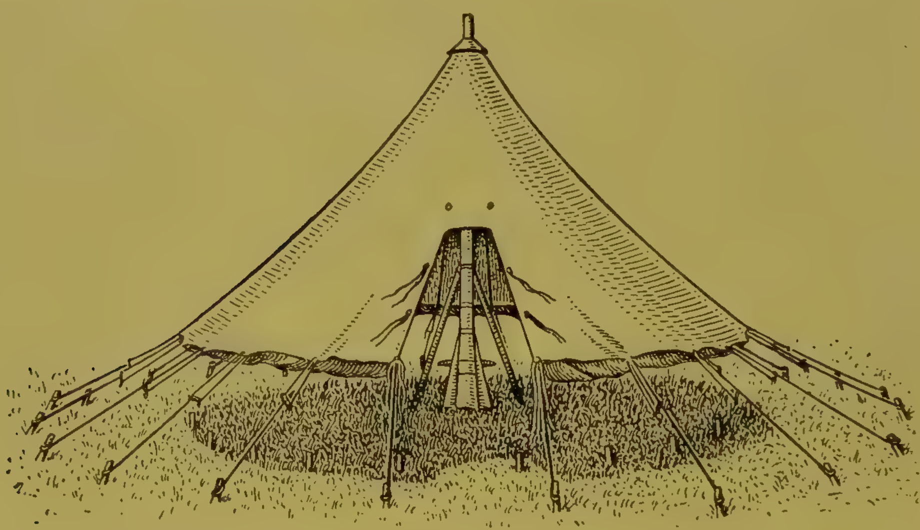


FIG. 169.—Conical wall tent, improved, with walls rolled up (for cold countries).

It can accommodate 12 infantry men and 8 cavalry men (with horse equipments), if lying down on the ground, but only 6 men on cots.

This tent is not adapted to warm or tropical climates on account of its easily heated interior, resulting from the low walls and absence of fly, its temperature being from 4 to 8 degrees higher than that of a hospital tent under similar circumstances (Maus and Lyster).

The improved conical wall tent (model 1904) is intended for permanent camps in cold climates where the use of stoves is absolutely necessary (Fig. 169). It has the shape and dimensions of the preceding, but the pole is replaced by a stout stovepipe resting upon a tripod and connected with a specially constructed conical stove placed within the tripod. Near

its summit the stovepipe has a collar upon which rests the circular opening (7 inches in diameter) forming the top of the tent. This opening is protected from rain by a galvanized-iron cap. At the top of the pipe is inserted a spark arrester.

Hospital Tent.—Two types are provided, the regulation hospital tent and the tropical hospital tent.

The regulation hospital tent (model 1907) is 11 feet high to ridge, 14 feet 4 inches long, 14 feet 6 inches wide, with wall 4 feet 6 inches high and doors 8 feet 9 inches high (Fig. 170). It requires one ridge, two upright and four eave poles, 18 large double-notched pins and 26 smaller pins.

FIG. 170.—Hospital tent, regulation, showing interior.

It weighs complete, with poles and pins, about 200 pounds. In each end there is a circular "ventilator and stovepipe opening" consisting of an Army standard stovepipe collar, sewed in and reinforced, which can be closed by an inside flap. This opening serves as ventilator in summer and for the stovepipe in winter. The hospital tent accommodates 5 or 6 cots.

The old model differs from the above chiefly in being 4 inches shorter and in having rectangular openings in the end walls (Fig. 171).

The tropical hospital tent (model 1907) is 12 feet high to ridge, 10 feet 6 inches to base of pocket, 14 feet 4 inches long, 15 feet 7 inches wide, with wall 4 feet 7 inches high and doors 10 feet 3 inches high (Fig. 172). The

sides of the roof, 18 inches from the apex, are drawn in, the whole length of the tent, by a horizontal band of canvas, 18 inches wide, which forms the floor of an attic or "pocket." This floor is perforated by 4 holes one foot

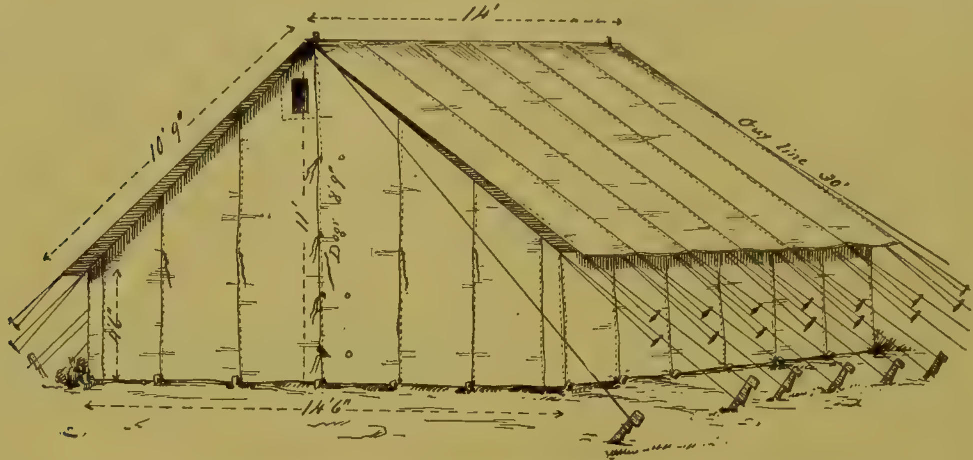


FIG. 171.—Hospital tent, regulation, former model. (*Munson.*)

FIG. 172.—Hospital tent, tropical, with fly.

in diameter, for ventilation, and by 2 smaller holes (one near each end) for the upright poles to go through (Fig. 173). The pocket has 4 holes on each side, 6 inches in diameter, the center of holes being 6 inches from the

floor. These side holes can be covered by a small fly 6 feet long by 14 inches wide, with lines to brail it up and haul down. This small fly is especially intended for use in the absence of the regular large fly (Fig. 174). The pocket can be closed at each end by a triangular flap 18 inches wide at base and 14 inches long. This tent requires one ridge, two upright and four eave poles, 36 large double-notched pins and 26 smaller pins. The ridge pole is 18 feet long, spliced in center with a 12-inch thimble joint protected by a sleeve 30 inches long, and with hole for the spindle of upright pole 2 feet from each end.

FIG. 173.—Hospital tent tropical, showing interior.

The ridge pole projects 2 feet beyond the upright at each end. The fly is sufficiently long to cover this extension and be secured to a stud at the end of the contiguous ridge pole, so that a completely covered space, 4 feet long, is provided between the tents.

Besides the ventilation produced by the holes in the floor and sides of the attic, the drawing in of the roof separates it from the fly and increases the insulating layer of air between them.

This tent is simpler and more durable than the Munson tent which it has superseded.

Of tents used in foreign armies none appear especially suitable to our service or to possess advantages over those above described, with the ex-

ception of the *wagon* or *tortoise tent* officially adopted by the English and French and well worthy of special mention. It is rectangular in shape, 23 feet long by 21 feet wide and weighs, complete, about 200 pounds. It is carried on top of an ordinary army wagon, forming its roof, the sides being rolled up and supported on brackets. For use, it is unrolled all around the wagon, which takes the place of a ridge pole, and held up by 16 light poles and a sufficient number of pins. It is lighted by windows made of an oiled, translucid fabric. All necessary furniture and supplies

FIG. 174.—Hospital tent, tropical, showing ventilation of attic.

are carried in the wagon. This tent can accommodate 16 cots or about 30 patients lying on the ground. The facility with which it is pitched, furnished and supplied, independently of the baggage train, gives it great value. In the colonies or wherever vehicles cannot go, the wagon is replaced by a ridge pole and the whole outfit carried by pack animals.

Two other tents are also officially recognized in the French Army, the Tollet and the Herbet tents, with heavy metallic framework and rather complicated structure, therefore not adapted to our service, although (the Herbet tent especially) offering great sanitary advantages and comforts.

IMPROVISED AND PORTABLE BARRACKS.

Where timber is abundant and the camp is to be of some duration, log huts with well-plastered joints, canvas roof and fly, afford excellent

FIG. 175.—Log hut with canvas roof. (*Smart.*)

shelter and are preferable to tents. For light and ventilation they should have openings at both ends and in the door, which can be closed with sashes of translucid fabric (Fig. 175).

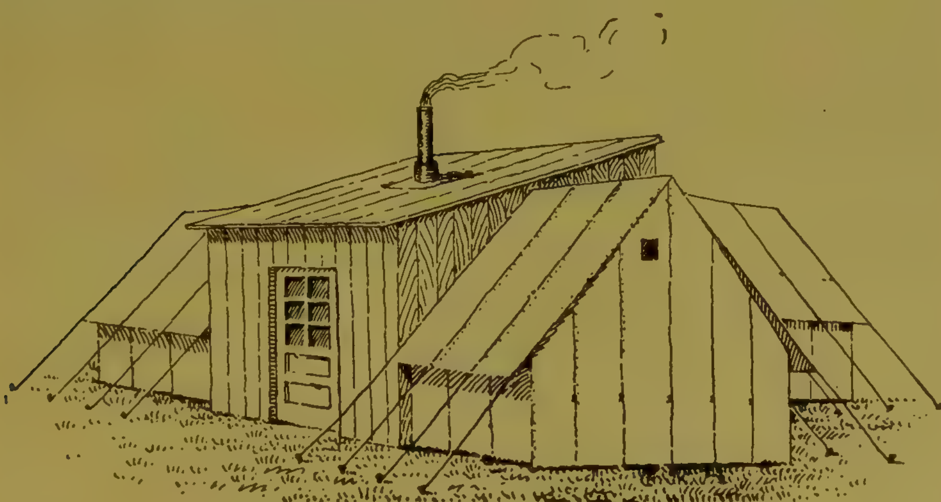


FIG. 176.—Falk's arrangement of tents in winter quarters.

For winter camps, an excellent arrangement is that devised by Falk, in which 3 wall tents or common tents are placed against three sides of a

small, square, frame cabin, each tent connecting with it by a door (Fig. 176). A stove or fire in the cabin warms the tents; around it the men gather to smoke and lounge.

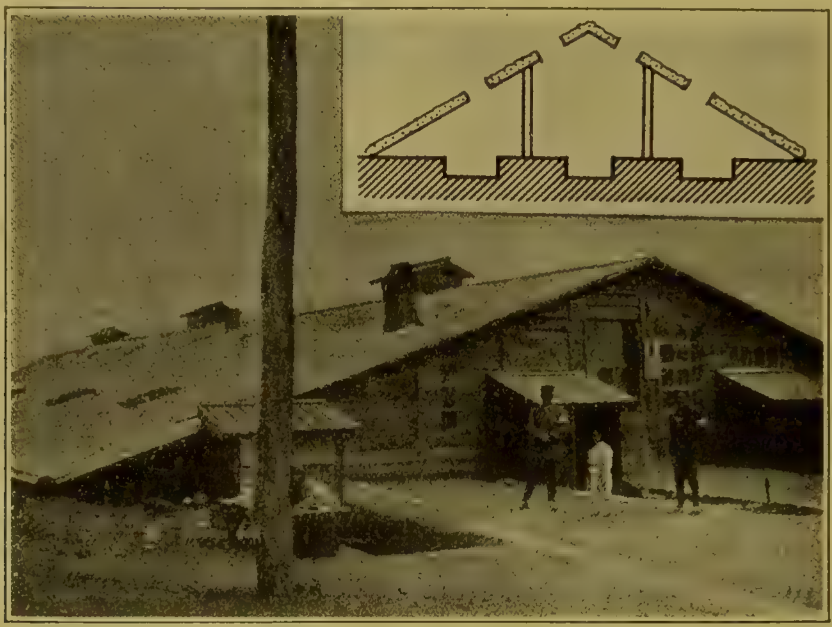


FIG. 177.—Underground Russian hospital at Mukden, Manchuria.

When campaigning in very cold countries it may be advisable to construct dugouts, that is to say, huts partly excavated in the ground and covered with mud roofs, as was done on a very extensive scale by the

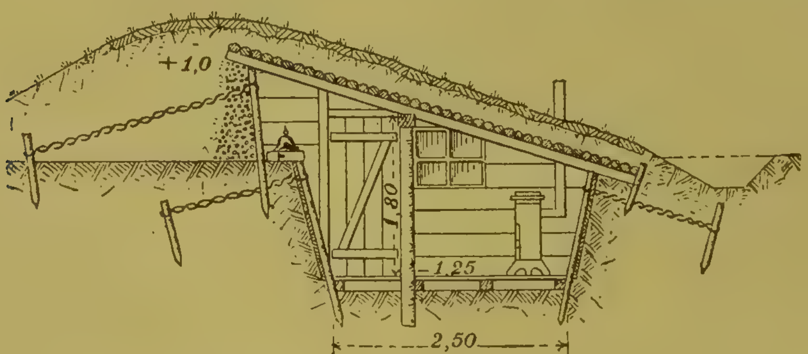


FIG. 178.—Dugout used by the German Army. (*Munson.*)

Russian and Japanese soldiers in Manchuria. Such dugouts have the advantages of being quickly and cheaply constructed, easily heated and not conspicuous. On the other hand, they are difficult to police and

FIG. 179.—Portable hospital pavilion, system Ducker.

FIG. 180—Portable hospital pavilion with double roof and double floor, system Ducker.

ventilate, and likely to be insanitary. It should be noted, however, that the health of the Russians and Japanese in Manchuria did not appear to be in any way impaired by their prolonged stay in such underground structures during the winter of 1904–5. The main reception hospital of the Russians, at Mukden, near the railroad station, was of this type (Fig. 177). In sandy soil, the sides of the excavation should be retained by boards and stakes as in the German type (Fig. 178).

For cantonments, light frame barracks of various models have been devised. In the United States they are generally heated by stoves, their ventilation being chiefly by natural perflation, but also, in winter, by ducts which bring fresh air under the floor to the stoves, the foul air escaping through shafts enclosing the stovepipes.

Fig. 181.—Portable hospital, system Doecker.

An excellent workable type of portable buildings, on the knock-down system, for our cantonments and permanent camps, has been devised by the Quartermaster's Department. They are especially intended to shelter latrines, lavatories, incinerators, kitchens and messes, and will be found described under their proper headings.

Portable barracks are more or less used in all countries for the shelter of troops as well as for hospital purposes. The two best-known types are the Ducker system manufactured by the Ducker Co., of New York, and the Doecker system manufactured by Christoph & Unmack, of Niesky, Germany. The Ducker buildings consist of sections 2 feet 9 inches wide, easily set up and secured, without nail or screw, and have all the advantages of permanent structures, while capable of being speedily knocked

down and reconstructed. By the addition or removal of sections they can be increased or reduced to any desired extent (Fig. 179). Another model is shown in Fig. 180, a tuberculosis-hospital pavilion at Bellevue Hospital, New York. These portable buildings seem to be particularly well adapted to the needs of permanent summer camps at home and in our colonies.

The Doecker portable hospital was often seen in Manchuria during the Russo-Japanese War, being much used by Red Cross societies with entire satisfaction (Fig. 181).

FORM OF THE CAMP.

When not in presence of the enemy, battalions and squadrons usually camp in column of companies or troops at convenient distances.

With shelter tents the arrangement for each company will be in two lines, facing each other, with a distance of 15 to 20 yards between the lines; this space forms the company street. A company of infantry thus occupies a space of 20 to 25 yards in depth.

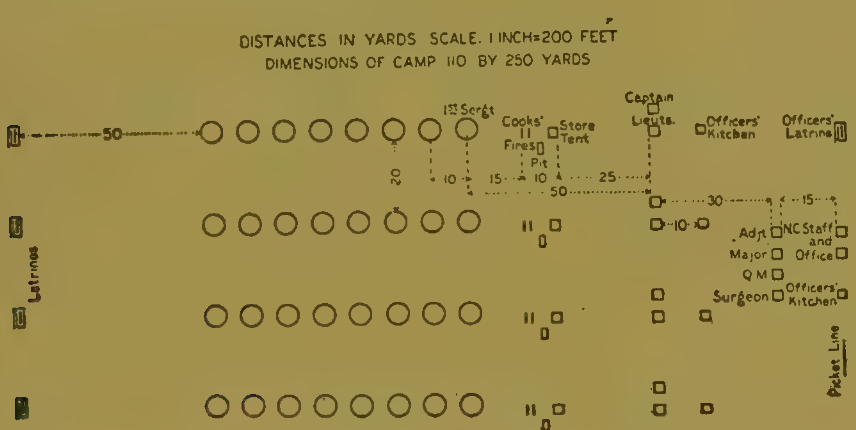


FIG. 182.—Camp of a battalion of infantry.

The picket lines of troops of cavalry will be about 40 yards apart, those of batteries about 100 yards. The shelter tents, all facing toward the head of the column, are placed in one row, about 15 yards in rear of the picket lines, or in two rows with 5 yards between rows.

With common tents, or with wall tents, the camp is usually formed in two lines for each company, and in one or two lines for troops or batteries.

With conical wall tents a single row is the most convenient form for each company, troop and battery.

The distance between tents in line, from center to center, is: for wall tents, 8 paces; common tents, 6 paces; conical wall tents, 10 paces. In

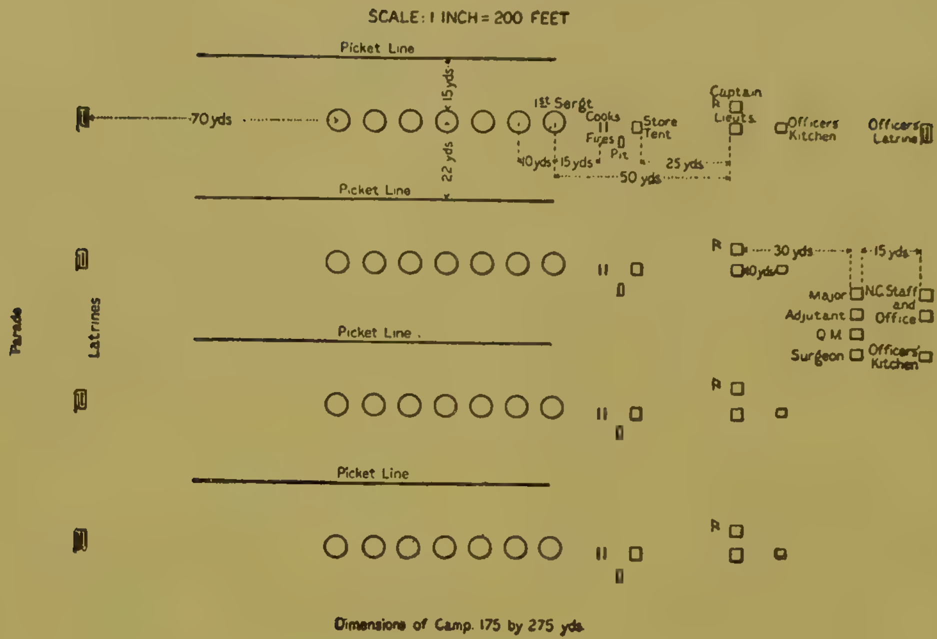


FIG. 183.—Camp of a squadron of cavalry.

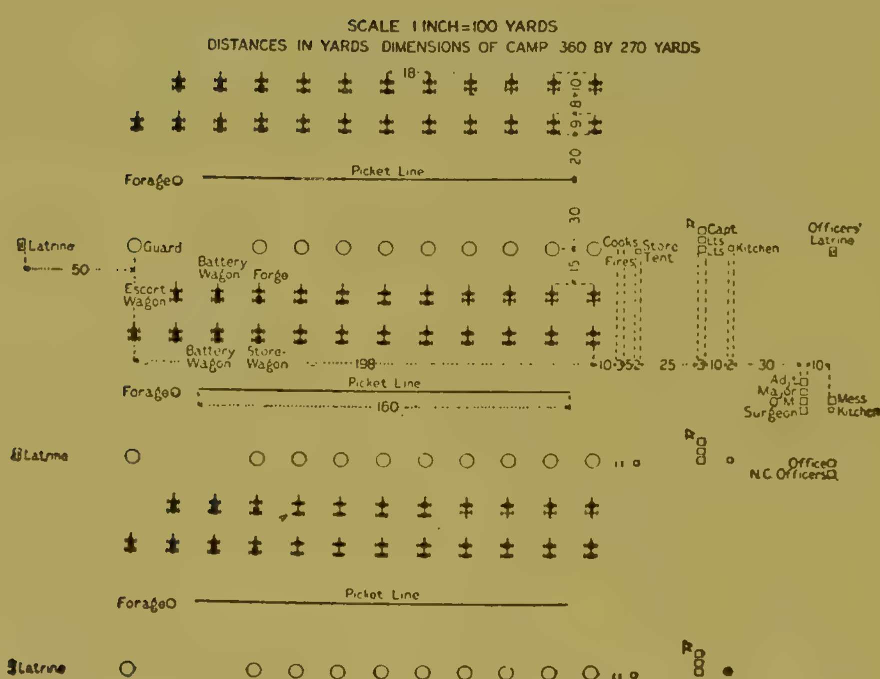


FIG. 184.—Camp of a battalion of artillery.

pitching tents, the wall or bottom pins are so driven as to slope slightly away from the tent; guy pins, so as to slope slightly toward the tent.

From the sanitary point of view, the great guiding principle, in forming camp, is to separate the kitchens and messes as far as possible from the latrines. Therefore, the rule is to place the kitchen on one flank of the company and the latrine on the other. Near the kitchen is the store tent, and a pit for liquid wastes when cans are not provided for the purpose. Next to the line of kitchens is the line of officers' tents, an unobjectionable arrangement which facilitates the inspection of the former, thus ensuring greater cleanliness and more efficient management.

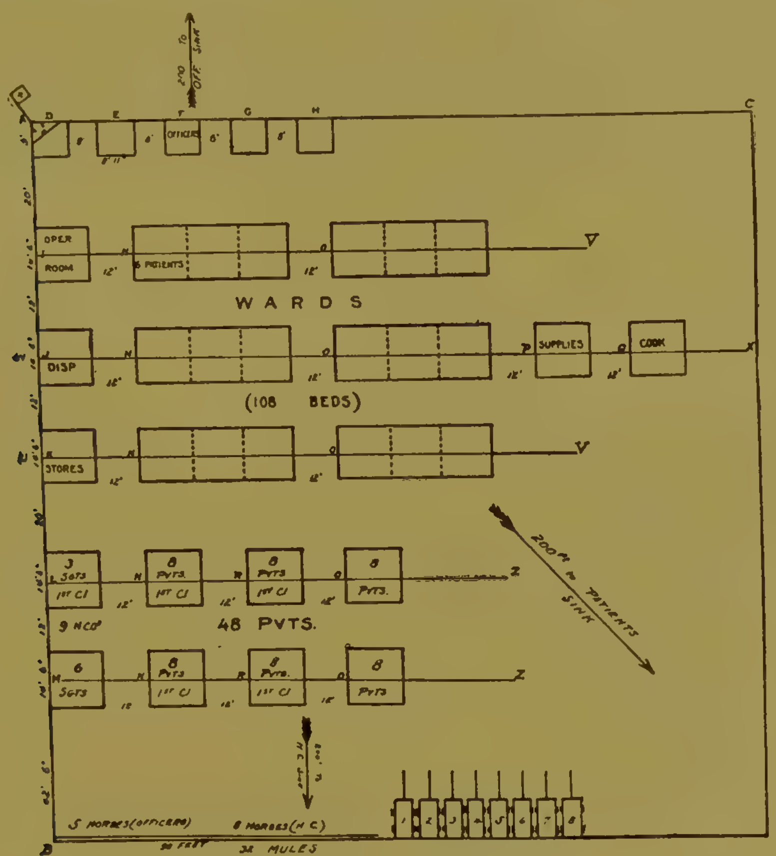


FIG. 185.—Plan of field hospital.

The Field Service Regulations prescribe the above plans for the several arms of the service (Figs. 182, 183 and 184). They are in accordance with the best judgment of military sanitarians, with the reservation that the kitchen pits are only to be resorted to when liquid wastes cannot be disposed of by a better method.

When a regiment is camping separately, or operating independently, it

should be accompanied by a complete regimental hospital, or as complete as transportation permits. When it is brigaded, no regimental hospital is

FIG. 186.—Perspective of field hospital. Fort Riley maneuvers, 1902.

necessary; only an "infirmary" is put up, consisting of one hospital tent and one or two wall tents, all hospital patients being sent to the field hospital. This infirmary is placed in the best available site, as free from

FIG. 187.—Livonian field hospital, Mukden, Manchuria. 1, portable Doecker pavilion; 1, large Russian hospital tents; 3, tortoise tent on ridge pole (system Lefebvre); 4, Mongolian felt tent; 5, small frame barrack for personnel.

dust, noise and flies as possible. As it keeps only trivial cases, there is no objection to its location near the men's or officers' rows.

One field hospital is usually assigned to each brigade. It should be

in an easily accessible site, near a good water-supply and without too much regard to its distance from the regiments for which it is intended. It generally consists of six wards, each of three hospital tents, and such other tents as are required for administration, service and quarters (Fig. 185). A perspective view of such a hospital is given in Fig. 186. In the course of a campaign, in the absence of suitable buildings, it may be necessary to utilize all available shelters; this is well illustrated in Fig. 187 representing a field hospital at Mukden, Manchuria, during the Russo-Japanese War.

ESTABLISHMENT OF CAMP.

Upon arriving at the selected site, the first duty which concerns the medical officer, if the matter has not previously been attended to, is an examination of the water-supply and the determination of the place or places where drinking and cooking water should be drawn. Below this, if the supply is from a stream, other places should be likewise set apart for watering animals, for bathing and washing clothing, in the order named.

If the stream be small it will be of advantage to construct reservoirs by building dams.

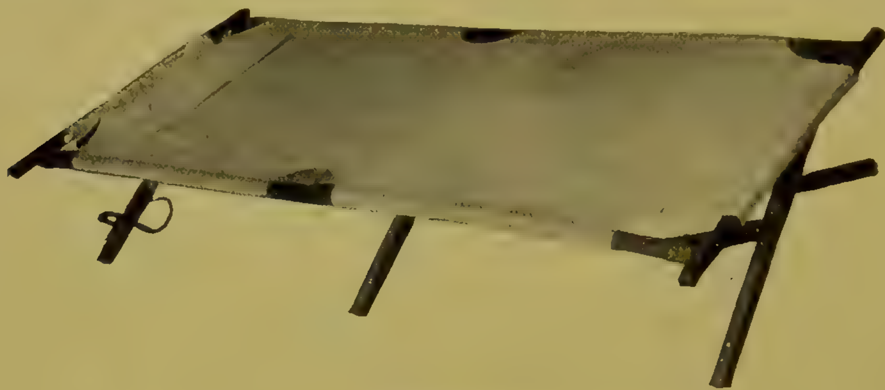
Small springs may be dug out and lined with stones, brick, or empty barrels. Surface drainage is kept out by a curb of clay. Animals will in such cases generally have to be watered from troughs or buckets.

If the water be of doubtful quality, measures must be at once taken to filter or sterilize it.

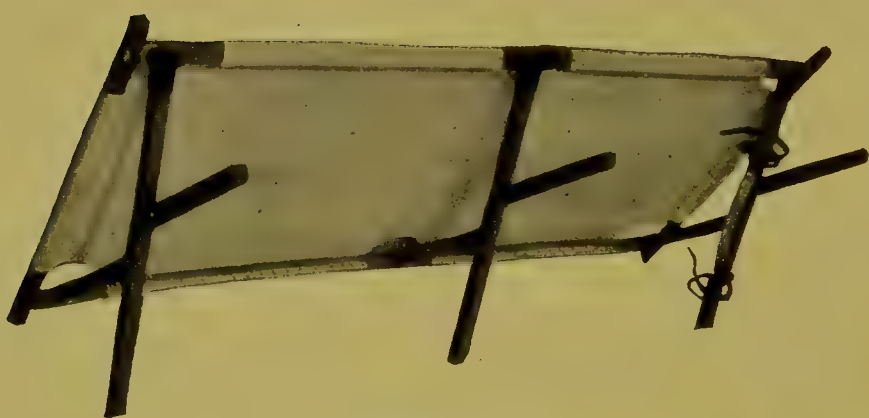
The next thing requiring the attention of the medical officer is the digging of the sinks. This should be begun as soon as the company lines have been laid out and suitable spots designated. According to the Field Service Regulations, upon going into camp, "details should be made immediately to dig latrines and kitchen pits. . . . At the end of a march latrines should be constructed as soon as tools become available." This means that they should be ready by the time the camp is pitched. Were it otherwise, men will stray beyond their lines and almost inevitably ease themselves wherever they have a chance to do so unseen by their officers, thus violating the first and most important law of camp sanitation.

In case tools are not available or, for other reasons, the digging of latrines is unavoidably delayed, the regimental medical officer should recommend a suitable place to the colonel for the provisional use of the men, where narrow shallow trenches are dug if practicable. In any case, such place should receive careful ulterior treatment, all fecal matter being buried or well covered.

"Tents, company streets and picket lines will be ditched if there be time available." The earth from the ditch is usually thrown away from the tent; it should never be thrown upon the sod cloth and against the bottom of the tent wall, unless absolutely necessary to prevent extreme cold or a



Top View



Bottom View

Folded

FIG. 188.—Regulation folding cot.

dangerous irruption of rain-water; in such position the earth interferes with ventilation, prevents the lifting of the walls and, by favoring dampness, impairs the strength of the canvas.

The digging of a small gutter, 4 to 6 inches deep, around tents is simply for the purpose of keeping their floors dry; therefore when the

camp is only for a day or two and there is a reasonable certainty that no rain will fall, such digging is unnecessary; but under ordinary circumstances it should not be neglected. These gutters should lead into the trenches of the company street and these into larger ditches so that the whole camp may be properly drained.

The installation of a camp, so far as the comforts of the men are concerned, will depend chiefly upon the length of time it is to be occupied; thus if it is to last a week or more, the grounds should be cleared of all underbrush, paths and roads ditched, bedded and gravelled; rough chairs, benches and tables may be constructed, as well as shades over mess tables, latrines, bathing and washing places, etc. These simple improvements are easily made and add greatly to the contentment of the men; but so far as the sanitation of the camp and the health of the men are concerned, it matters little what the stay is to be, whether short or long, the sanitary measures are practically the same and to be applied with equal strictness, especially in everything that concerns the correct disposal of excreta and wastes.

Soldiers, so far as possible, should not sleep on or too near the ground: 1, because the soil is often damp, even when apparently dry, moisture rising up very readily from the wet subsoil by capillarity; 2, because the soil being liable to be infected by disease germs, blankets and clothing should be lifted above it; 3, because the atmosphere near the soil is always more or less contaminated by ground air which, as stated before, contains a large proportion of carbon dioxid and other obnoxious gases resulting from the decomposition of organic matter, especially in hot climates.

In cantonments, or permanent camps, the tents may be pitched in frames and floored, and bunks constructed or cots used. In winter, stoves may be supplied and placed upon brick or stone foundations. The regulation "folding cot" which has been used in our Army for a number of years has been found entirely satisfactory (Fig. 188). In temporary camps, the Quartermaster's Department supplies bedsacks which the men stuff with straw, grass, leaves or brush. In the absence of cot and bedsack, the soldier can generally make himself a couch of the same material or improvise a bedstead with a few stakes and cross sticks. If none of these things be available he should spread his poncho or slicker upon the ground, under his blanket.

CHAPTER XXXIII.

LATRINES.

Fecal matter is not only repugnant to sight and smell, but, in camp, constitutes the chief source of danger to the health of the soldier. It may contain various infectious germs and from it are spread the camp diseases most to be apprehended, namely, cholera, typhoid fever, dysentery and diarrhea. As it is always difficult and often impossible to detect cases of these diseases in their early prodromal stage, or before patients have a chance of polluting the latrines, the first sanitary axiom to promulgate in a camp is that all excreta (fecal matter and urine) are to be considered as infected and treated accordingly. A firm mental grasp of this axiom helps to a clearer understanding of the peril to which the men are exposed and suggests the measures best calculated to guard against it.

Fecal matter and urine convey the germs of disease through food and drink, that is to say, by being directly ingested into the stomach. There is also a probability that these germs, as they float in the air dust, are absorbed by inhalation.

Water contaminated by sewage or the seepage from latrines has been a widespread cause of typhoid fever and cholera. But this danger is so obvious and now so well understood that, it can be assumed, few officers will allow their men to drink water, not declared safe by the sanitary officer, without previous sterilization or filtration. Flies are also an active agent of infection, carrying thousands of germs in the minute particles of excreta adhering to their feet. Another prolific cause of the spread of typhoid fever, and probably cholera and dysentery, in camps, is personal contact, that is, the dissemination of fecal matter from man to man, through the clothing, shoes and hands. Human excrement, therefore, must always be looked upon with great suspicion, as a menace to the health of the camp, and be the object of the strictest sanitary measures.

The Privy-pit or Sink.—The ideal disposal of excreta in camp is incineration. When this is not possible, the next best method is disinfection and removal (by sanitary trough and excavator). But in temporary camps, where troops remain only for a night or a few days, or whenever the necessary sanitary appliances are not on hand, no better system has as yet been devised, and probably ever will be, than the primitive privy-pit.

Whenever troops go into camp, even if only for a few hours, latrines are necessary. If the stay is only for the night the pits need not be more than 2 feet deep; 3 feet if for two days, 4 feet if for three days, etc.

For a day or two, a mere trench, such as used by European armies, the width of the spade or shovel (not to exceed one foot) and a depth of one or two feet, is generally sufficient. The men squat astride of it, in complete security. No pole and supports are necessary, and there is very little danger of fouling the edges. Should several trenches be needed they can be dug parallel to each other, the earth from each new one being used to fill and cover the last.

If the camp is to be for a week or more, the pit must be dug full depth; this will vary according to the nature and composition of the subsoil and

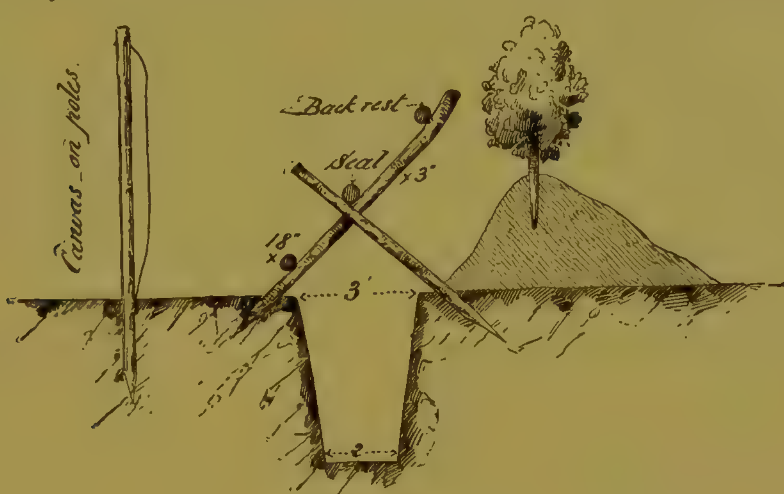


FIG. 189.—Construction of pit latrine. (*Munson.*)

underlying strata, and also the depth of the ground water. A shallow pit may be imposed by a rocky stratum, loose sandy soil with tendency to cave in, or by the ground water rising near the surface.

It should be borne in mind that the deeper the pit the greater is the danger of contaminating the ground water and, therefore, any source of water-supply in the near vicinity, and the further fact that the nitrifying bacteria, through whose agency fecal matter is disintegrated and mineralized, are mostly in the upper 3 or 4 feet and that their action is very feeble below a depth of 6 feet. However, considerations of convenience and economy of space and labor make it generally advisable that, whenever possible, the depth of the pit should be at least 8 feet. A convenient average width is 3 feet at the mouth and 2 feet at the bottom (Fig. 189).

Sinks should never be located in the lower part of the camp where they are liable to contaminate ground water, and exposed to be flooded in rainy

weather; as a rule they must be on as high grounds and as far away from the water-supply as possible.

The length of the sink must be such as to afford accommodation for from 5 to 8 per cent. of the command. Under normal conditions the smaller of these percentages will suffice, but as outbreaks of bowel complaints may occur at any time it is better to make more liberal provision. By allowing two feet to each man, a trench 20 feet long will seat 10 men, or at least 7 per cent. of an infantry company at its maximum strength of 128 men. For a battery of field artillery, 160 men strong, the trench should be 25 feet. To this length should be added 4 feet to provide for 2 urinals, one at each end, as explained further on.

The question suggests itself whether each company should have its separate sink or if it is not preferable to have only one longer trench for the battalion. The latter system is certainly economical of time, labor and space; it is easier to dig one trench 80 feet long than four separate ones 20 feet long; but, on the other hand, the shorter pits can be placed nearer their respective organizations and maintained in a more perfect state of police. The question will be largely determined by the local conditions of terrain, soil, ground water and by the form of the camp. A very satisfactory compromise is to have one trench for each two companies, with brush partition across the middle.

In digging the pit, the excavated material is usually piled along the edge of the rear side. This material, or as much of it as is good for the purpose, will be used as disinfectant; it is desirable, therefore, if a notable proportion of it should consist of coarse gravel, chalk or stone, to throw it further back and pile the loam and other available earth along the edge of the pit. The usual latrine seat is made up of a smooth straight pole or sapling, with bark shaved off if possible, resting upon crossed logs. These supports are placed at intervals of 8 or 10 feet, each set consisting of two logs planted opposite each other, one in each edge, at such angle that they cross each other about 18 inches above the mouth of the pit, about a foot from the front edge; in this position they are securely lashed or otherwise fastened together. Besides the seat placed in the angle of the supports, two other horizontal poles must be secured to the front logs, one as a foot rest and protection to the front edge, just high enough to clear the ground, another as back rest and guard, 15 inches above the seat. The front logs, therefore, must be about 2 feet longer than the rear ones. (Fig. 189).

The latrine, if intended for more than a day or two, should be sheltered from the sun and given as much privacy as conditions permit. It may be covered over with a tent fly and protected, front and rear, by pieces of

canvas; or a roof and walls of poles, brush and grass can be constructed. This additional work gives comfort to the men and, what is more important, obscures the latrine and renders it less attractive to flies. This obscurity, however, should not be so great as to prevent a clear view of the seat, edges and contents for purposes of policing and disinfection.

One part of the pit must be reserved for urination, preferably one end or both ends of it. For this purpose the crossed poles holding the seat should be set in a couple of feet from the ends; the space thus set apart as urinal may be still further isolated by a brush partition thrown across the trench. The passing of urine which accompanies defecation necessarily takes place in the latrine, but, at any other time, urination in any places but those specially prepared and designated must be strictly prohibited. Thus only can the edges and surroundings of the latrine be guarded against urine pollution.

The last requisite to make the sink complete is a draining ditch around it, or at least on the sides from which drainage water might be expected. This is very important; otherwise a heavy rainfall may flood the trench, scatter its contents over surrounding grounds and do irreparable harm.

Sink Box.—Whenever a camp is to last more than a week, especially if it is to assume a permanent or semi-permanent status, the Regulations provide special systems of disposal as described below. But in war time, during a campaign, particularly in a foreign country, owing to the great difficulty of transportation, the application of such complex systems will often be impracticable and sinks made necessary for indefinite periods of time. The question is then how to render these pits as little objectionable and harmful as possible. There is a consensus of opinion that they should be "boxed" so as to convert them into dark vaults more easily policed and from which flies can be excluded. Few writers appear to have practical ideas on the subject. The box should be so constructed that the timber, always scant and valuable under the circumstances, will suffer no serious damage while in use and that its parts can be readily removed and carried to each new trench. A knock-down transportable box is therefore necessary, and should be so made that no part of it is exposed to pollution.

In the system devised by the writer and here recommended, the latrine box is 10 feet 6 inches long, 16 inches high and 3 feet 8 inches wide at bottom so as to safely cover a pit 3 feet wide (Fig. 190). The sides or walls have an inward slant of 4 inches and are locked together by the end pieces and two traverses. The top consists of two longitudinal halves, simply laid on and kept from slipping by blocks; each 21 inches wide, projecting 2 inches beyond the side, and perforated by 3 holes which alternate

with those of the other half. Each hole, 11 inches long, is covered with a strong hinged lid which can only be raised to an angle of 45°, so that it is self-closing and prevents standing on the edge of the box.

Each box consists of 8 pieces perfectly interchangeable with those of any other box, and weighs 175 pounds. It can be put together without screw, bolt or hook, or taken apart, by one or two men in a few moments. To disinfect the pit, the attendant lifts the half of the top nearest to the earth pile and shifts it over the other half, thus uncovering the pit and obtaining a good view of the contents (Fig. 191). One pit 10 feet long covered with

FIG. 190.—Movable latrine box.

this box will do for a company for a week; if the stay is to be longer, the pit should be of the standard length of 20 feet and 2 boxes used, end to end.

For urinals: tubs, cans or boxes must be provided, one at each end, with a pipe, gutter or trench leading into the pit.

Police and Disinfection.—In order to promote personal cleanliness and prevent as much as possible the transmission of infection by personal contact, the men should be enjoined to use paper in latrines, preferably the ordinary thin toilet paper. The Regulations provide for the issue of toilet paper in camps whenever practicable. The use of paper, however, especially light tissue paper, requires great care; the least breeze

will often prevent its falling into the sink, while a stronger wind may blow it up and scatter it over the camp grounds. It should be one of the special cares of the attendant to guard against this.

Another important measure to prevent fecal matter dissemination is to require the men to wash their hands, after defecation, before leaving the latrine. For this purpose, the attendant should have a bucket of clean water, a couple of basins and soap always in readiness, each man after washing emptying his waste into the urinal. When an infectious disease is present in camp or apprehended, it will be wise to dip the hands, after

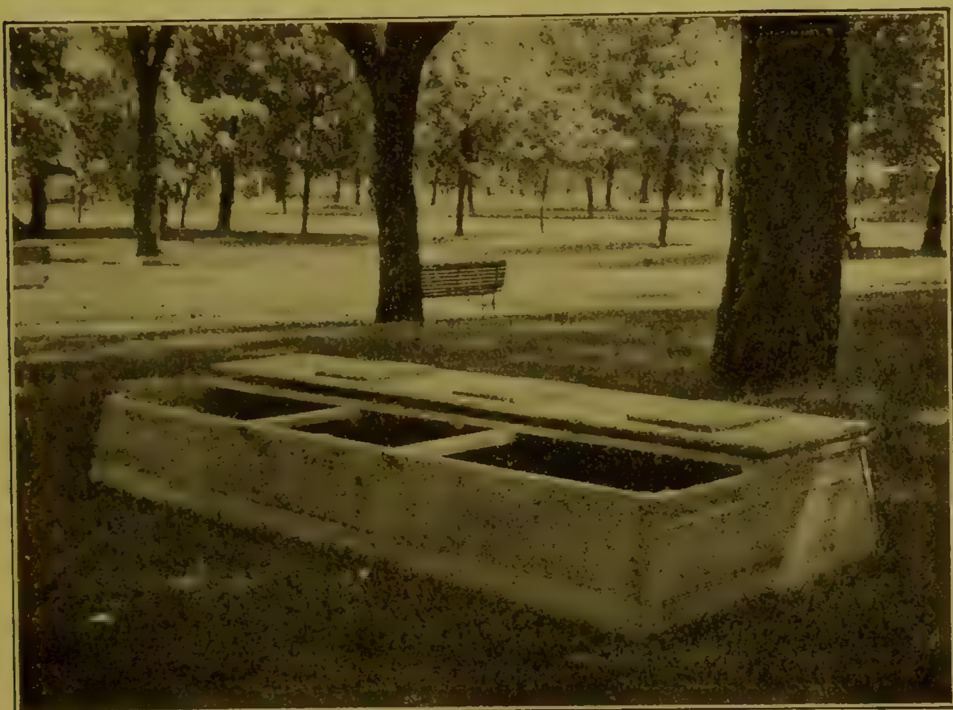


FIG. 191.—Movable latrine box, with one half of the top shifted over the other half for inspection and disinfection.

washing them, into an antiseptic solution of formalin, cresol, corrosive sublimate, etc. During one of their recent wars with the natives in South Africa, German troops were required, after defecation, to soak their hands in an antiseptic solution and, after washing, to wipe them with dry sand.

Strict cleanliness and efficient disinfection will prevent much of the danger lurking in the open sink. In the first place, it should be in charge of a civilian scavenger, or enlisted attendant, held strictly responsible for its sanitary condition. Every man using it must be required to cover

his discharges with a shovelful of earth. Furthermore, the attendant, twice a day, or oftener if deemed necessary, should make an examination of the contents and throw earth on any part of the surface not properly covered, not neglecting the fecal matter adhering to the walls. When earth is not available, lime may be used, but it should be one or the other, not a mixture of both. Earth is a deodorant and disinfectant; it absorbs offensive gases to a remarkable extent and brings about their oxidation and transformation; it promotes the multiplication of saprophytic bacteria and nitrifying organisms which feed actively upon all available organic matter and destroy it, with the result that they themselves speedily perish from lack of nourishment. Lime acts by destroying these organisms or preventing their propagation; therefore, if mixed, these agents would partly neutralize each other and lose much of their efficiency.

Other means of disinfection have been used with satisfactory results. For instance, straw, hay, dry grass, twigs or foliage may be thrown into the pit so as to evenly cover the contents, sprinkled with coal oil and then fired. This blazing is presumed to destroy all germs lying on the surface of the excreta and of the walls, and to discourage flies from visiting the latrine. Such method requires considerable fuel and labor, and precludes the construction of a roof (canvas or brush) over the sink for fear of conflagration. Coal oil simply sprinkled into the pit, without firing, is doubtless useful, not so much as a disinfectant than as an insectifuge, keeping away flies; but, if thus used, men should be cautioned not to smoke or strike matches in the latrine. In the absence of lime, any of the other regular disinfectants may be used; formalin is probably the best on account of its superior deodorant and insectifuge qualities.

The attendant should daily scrub the seat with soap and water, and carefully police the edges of the pit and urinals, sprinkling lime wherever fouling has taken place. One of his chief duties will be to see that toilet paper escaped from the latrine is promptly returned to it or otherwise safely disposed of. The easiest solution of this troublesome difficulty is, occasionally, to light a small open fire in which all loose paper, caught with a pointed stick, is readily consumed.

When the pit is boxed, the disinfection is entirely done by the attendant, at regular intervals, through the opening made by shifting one-half of the top over the other half. Other duties of the attendant will be to keep the seats scrupulously clean and see that the urinals are properly used and limed.

When a deep sink is filled within 18 inches of the top, it should be discontinued and, after removal of all the timbers, filled up with

earth; this should be piled a few inches above the surface to allow for sinking.

Objections to the pit latrine. These are obvious. We can assume that pathogenic germs may be present at any time in its contents, with resulting pollution of the soil and subsoil, and contamination of neighboring water-courses. The germs of typhoid fever in contact with soil and fecal matter may, under favorable conditions, multiply for an indefinite period of time so that an old pit may be a source of danger when dug into several months after its closure. The pole used as seat is much exposed to fouling, and so are the edges and immediate surroundings of the trench, often wetted by rain and offering favorable conditions for the rapid growth of certain pathogenic germs. One of the chief dangers of the privy-pit is its free accessibility to flies which may thus easily transmit infective matter to the kitchen and mess tents. Toilet paper blown out of it is also a constant menace. This latrine is rendered much less objectionable by the addition of the boxed top described above; but the invariable rule should be to discontinue its use as soon as a more satisfactory system becomes available

Night Urinal.—Whatever form of latrine is used, it is essential that a special night urinal be provided. During the day there is no great danger of the men urinating outside the latrines, for fear of discovery, but at night, careless men are strongly tempted to relieve themselves as near their tents as is convenient. An iron can should be placed in each company street as urinal, with a red lantern over it, so that no one may have an excuse for polluting any part of the company grounds. This can should be emptied and cleaned out at reveille. During the day it may be kept near the latrine and used to collect refuse.

SANITARY TROUGH LATRINE.

Several improved systems of disposal for permanent or semi-permanent camps are in use in our service.

The sanitary trough latrine was one of the remarkable results of the investigation of the medical board appointed to determine the causes of the typhoid fever epidemics which decimated our camps in 1898. This board, consisting of Major Walter Reed, Major Victor C. Vaughan and Major E. O. Shakespeare, soon realized that the open sinks were responsible for the prevailing infection and recommended a system whereby all excreta are disinfected and removed from camp.

The trough latrine (as described in specifications from the office of the

Quartermaster General, January, 1908) consists of a small, well-ventilated frame building 28 feet long in front, shorter in rear, 8 feet 7 inches wide,

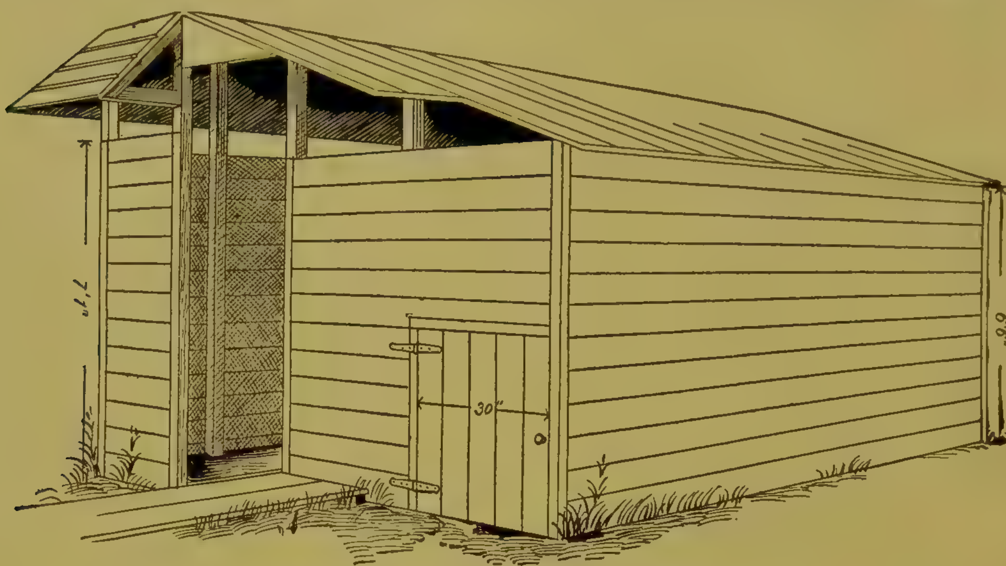


FIG. 192.—Shed for the trough latrine.

with doorless opening at each end, containing the trough and urinal (Fig. 192). The trough, of galvanized iron, is 14 feet long and 22 inches wide at top, with sloping bottom 15 inches deep at upper end and 18 inches

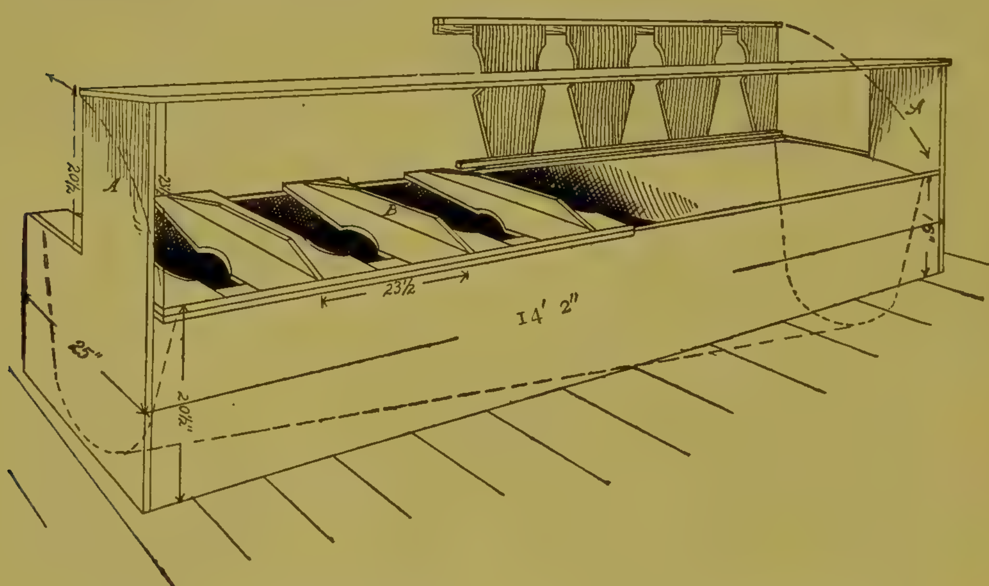


FIG. 193.—Perspective view of latrine trough; section of lid open.

at lower end; it is parabolic in cross section so as to present a curved surface throughout, thus avoiding corners in which the contents could

collect and facilitating emptying and cleaning (Fig. 193). The seat has 7 openings and is made of 8 separate pieces hinged to a board in rear. The openings are 8 1/2 inches in diameter, properly bevelled on edges, with cuts in front and rear to prevent fouling, the rear cut widening to 14 inches at back. At each end of the seat, and flush with it, is set up an upright

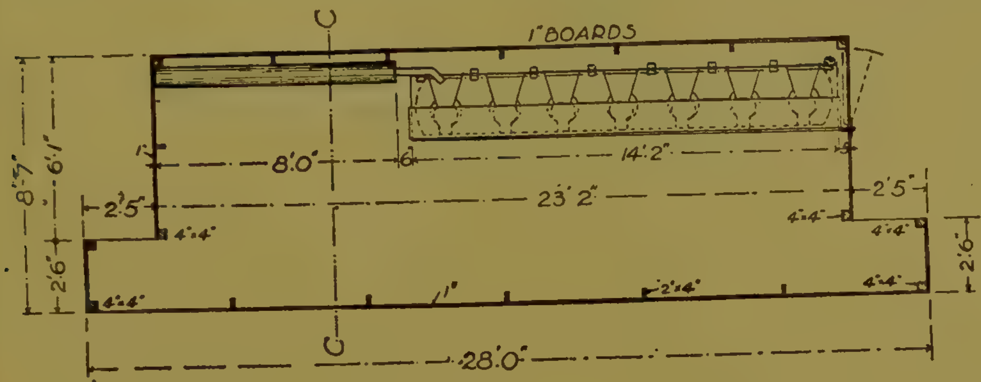


FIG. 194.—Ground plan of trough latrine showing seats and urinal.

32 1/2 inches high; on these uprights is nailed a board to prevent standing on the seat. (Figs. 194, 195)

The urinal is a galvanized rounded steel trough placed against the rear end of the building in line with the latrine trough, 2 feet 6 inches above the floor. It is 8 feet long, 8 inches wide and 4 inches deep, the rear side extending 18 inches upward to protect the wall. It has a fall of 5 inches and is connected to the latrine trough by a 2-inch galvanized steel pipe.

When ready for use, water should be poured into the latrine until it has a depth of at least 2 inches at the upper end. To this is then added 1/6 barrel of lime and the two well mixed with a wooden paddle. Lime should also be freely sprinkled in the urinal. By this means not only do the excreta immediately fall into a disinfectant solution, but the urine is also mixed with lime prior to falling in the latrine. To better provide for the disinfection of the excreta, the contents of the latrine should be stirred with a wooden paddle two or three times a day.

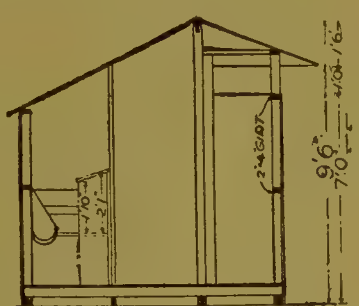


FIG. 195.—Section at C-C. of Fig. 194.

Once or twice a day the trough is emptied by the "odorless excavator." This consists of a wagon bed supporting a water-tight tank having a

capacity of 500 gallons, and a pumping apparatus mounted on a pair of wheels which track with the wheels of the wagon. For use, two lengths of hose are connected with the pump, one at each extremity; one free end is placed in the lower part of the trough through a hinged door in the wall of the building and the other free end attached to the pipe on top of the tank. The pump is rapidly worked by two men. As soon as the trough is emptied, the hose are disconnected from pump and tank, great care being taken that the ends of the hose and the openings of the pump are securely closed by the couplings or valves provided for the purpose, so that none of the contents be spilled on the ground. In camp or on the march the pump truck is hitched to the rear axle of the wagon. Each excavator requires the services of 3 men and disposes of the excreta of 2 or 3 regiments.

The sanitary trough latrine possesses decided advantages. It is very convenient for the men. It need not be more than 20 or 25 yards from the tents and may be placed wherever desired without regard to the water-supply, character of soil or depth of ground water. The general rule governing the location of latrines, that they should be as far as possible from the kitchens, is not as inflexible with this system as in the case of privy-pits. From the moment the excreta reach the trough they become disinfected and cease to be dangerous. Flies are less attracted than by open sinks and, if lids are used, can be entirely excluded. The floor, kept dry and hard, is much less likely to become polluted, while toilet paper does not readily escape from the trough. On the other hand, this system requires a heavy and costly material and would be impracticable during an active campaign. It would also be useless in very cold weather with the temperature below freezing-point. Water and plenty of lime are necessary. Furthermore, after the trough has been emptied by the excavator, there still remains the question of final disposal. It sometimes happens that this very heavy vehicle becomes useless in sandy or miry roads. The excreta may be dumped into sea-water or a stream, or into a large pit dug for the purpose, or may be utilized as a fertilizer on surrounding farms. If a pit is used it need not be more than a few hundred yards from camp, for the odor is only noticeable a short distance to leeward; as the contents are quite liquid, the danger from flies is slight and can be further reduced by pouring a little coal-oil on the surface. The organic matter, in spite of the lime, probably undergoes certain disintegrating bacterial changes so that the overflow from the pit, should there be any, may be safely allowed to run into any stream not used for water-supply.

EARTH-CLOSET LATRINE.

In camps where the trough latrine is not applicable or available, the earth-closet latrine has been provided. It consists of the same building, row of seats and urinal, but, instead of a trough, there is under each seat a galvanized steel box, 18 inches wide, 14 inches deep, 21 inches long from

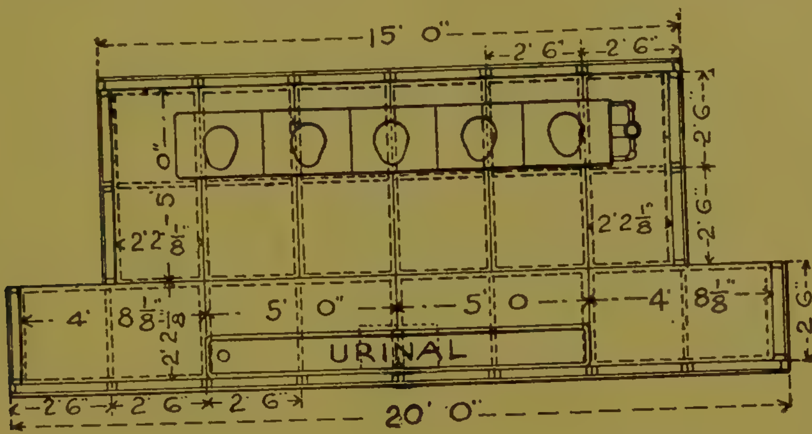


FIG. 196.—Field water-closet. Knock-down system.

front to back at top and 18 inches at bottom, the rear end being vertical and the bottom corners rounded. Each box slides out through a corresponding door upon a platform of joists extending 2 feet in rear of the wall. The contents of the boxes are disinfected with earth or lime. If lime is available, the boxes, before being used, are filled about one-fourth of their depth with milk of lime. The addition of a small quantity of crude carbolic acid forms a very effective disinfecting mixture. The boxes are taken out as often as necessary, emptied, washed and replaced. In cold countries or wherever there is danger of freezing, dry earth or lime is used

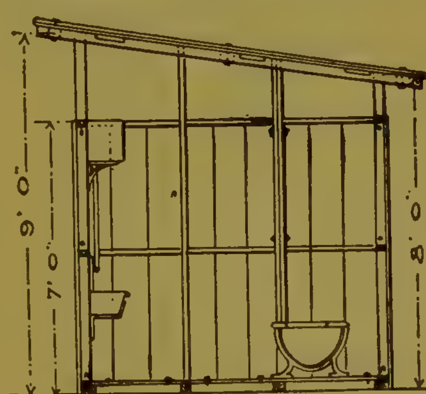


FIG. 197.—Cross section of Fig. 196.

KNOCK-DOWN BUILDINGS.

As a further improvement in the disposal of excreta, the Quartermaster's Department has devised knock-down buildings made up of separable sections of siding, roof and floor. The sections are 2 feet 6 inches in width and secured together with bolts and log screws. Such buildings are quickly put up and taken apart

without expert labor. They are intended for water-closets and earth-closets, as well as for lavatories.

The field water-closet (Figs. 196 and 197) consists of an automatic flushing range trough 11 feet 3 inches long, enameled inside, with 5 seats

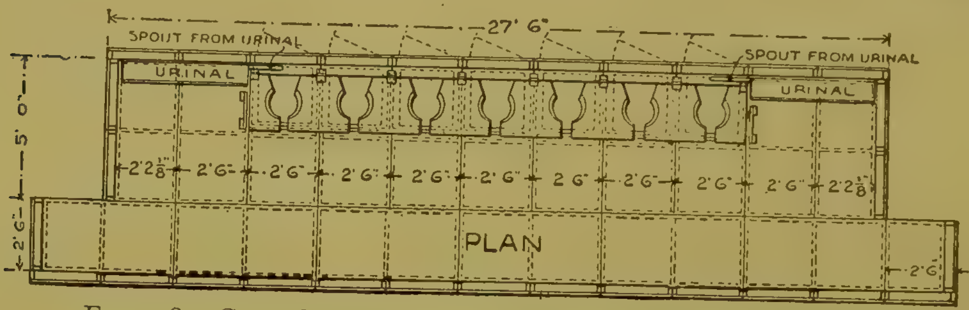


FIG. 198.—Ground plan of earth-closet latrine. Knock-down system.

and perforated wash-down pipes, the soil pipe being connected with the sewerage system or otherwise disposed of. The urinal is a trough in two sections of five feet each, with automatic wash-down and perforated flush pipe.

The knock-down earth-closet latrine is similar to the earth-closet latrine above described. The building is 32 feet 6 inches long in front (13 sections) and 27 feet 6 inches in rear (11 sections). (Figs. 198, 199). Instead of one urinal 8 feet long, there is one 4 feet 8 inches long at each end of the seats, a more suitable arrangement. The spaces occupied by the seats are greater and the boxes underneath wider, the latter being 21 x 21 inches at top.

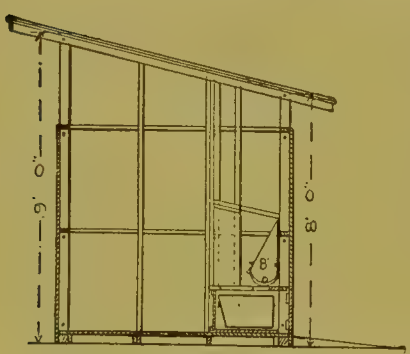


FIG. 199.—Cross section of Fig. 198.

DISPOSAL OF EXCRETA BY INCINERATION.

The ideal system of disposal is by incineration, that is, the destruction by fire of all excreta in the very pans in which they are received. This is realized in a highly satisfactory degree by the McCall incinerator which has in a large measure superseded the sanitary trough latrine. Other incinerators—especially the Lewis and Kitchen and the Conley—have been tried quite recently, and also give promise of excellent results. With this system no water or disinfectant is required, and as the residuum of combustion is a negligible quantity no further or final disposal need be pro-

vided for. It is also applicable to any climate and extreme of weather. All it needs is an adequate supply of fuel.

THE McCALL INCINERATOR.—This incinerator (Figs. 200-203) is installed in a knock-down building 22 feet 6 inches long in front and 15 feet wide. It comprises two sections at right angle to each other. Each section consists of a combustion chamber in a pit 24 inches deep, lined with brick (2), and of a steel box placed over the pit. In the combustion chamber are the two incinerator pans (25) in which the fecal matter is received. In the steel box, forming the top of the combustion chamber, are two hinged,

FIG. 200.—Perspective view of set of McCall incinerators used at the Jamestown Exposition.

wide plates (10) and three narrow, fixed plates (9). Each box is covered with a wooden lid or seat (13) in which 4 holes are cut, with covers closing automatically. Within the angle formed by the intersection of the two pits is a brick flue common to both. Upon this rests the smokestack base and upon the latter is placed the vertical smokestack (20). In the flue a grate is mounted (21), forming a second or auxiliary combustion chamber (18). A urinal (22), with hinged lid, corresponds to each section. From it a pipe (11), with valve (26), conveys the urine into the pan. The valve is only opened when the pans are fired. Another pipe (22^1) connects the urinal with the smokestack for ventilation.

For use, the two plates (10) are lifted up and the wooden seat is placed over the steel box. When the pans are full, the seat is removed and a fire of coke or coal made in the grate (21); the plates (10) are then lowered, thus forming a tight cover for the combustion chamber, and the pans are incinerated by burning wood in the pit underneath. This fire, however, is not to be started until the coke in the grate is thoroughly ignited and the auxiliary combustion chamber strongly heated; in this way all obnoxious gases are completely destroyed before they can escape from the smokestack. After the solid matter in the pans is incinerated, the valve under the urinal

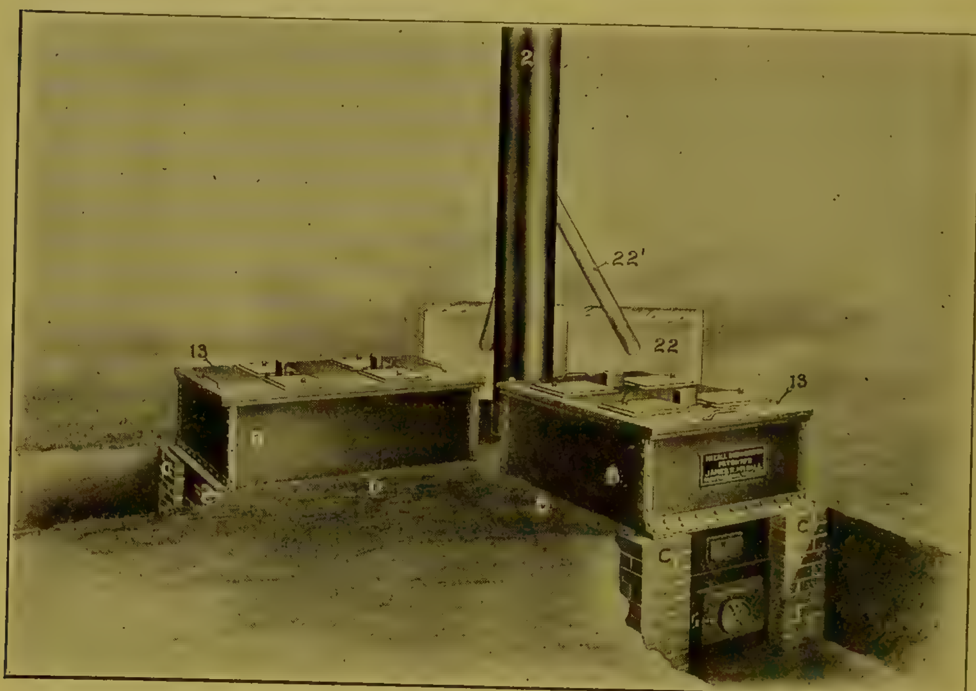


FIG. 201.—Perspective view of the two sections of the McCall incinerator.

is opened and the urine gradually discharged into the pan and evaporated. From 3 to 5 hours, according to size and quality of the fuel, are necessary to complete the incineration of excreta in one pit. Dry, hard wood, 4 feet long, is generally used as fuel. Each section is burned out once a day, or once every other day according to the strength of the company, the most convenient time being in the evening or at night, so that both sections may always be available during the morning hours.

It is evident that the McCall incinerator, as above described, is only available in camps of some permanency. In order to render it more transportable and mount it more rapidly on forming camp, without the

necessity of skilled labor, the inventor has replaced the brick-lined pit by a sheet-steel fire-box protected with asbestos. Thus improved this incinerator, complete, weighs about 1800 pounds; it can be knocked down in conveniently-handled pieces, easily transported, and set up, ready for use, within 15 minutes after reaching camp. For permanent camps, however, the brick pit is still considered preferable. The urinals have also been improved by giving them elliptical openings to prevent dripping.

The Jones Incinerator.—Capt. Percy L. Jones, Medical Corps, drawing his inspiration from the McCall apparatus, has shown how an incinerator

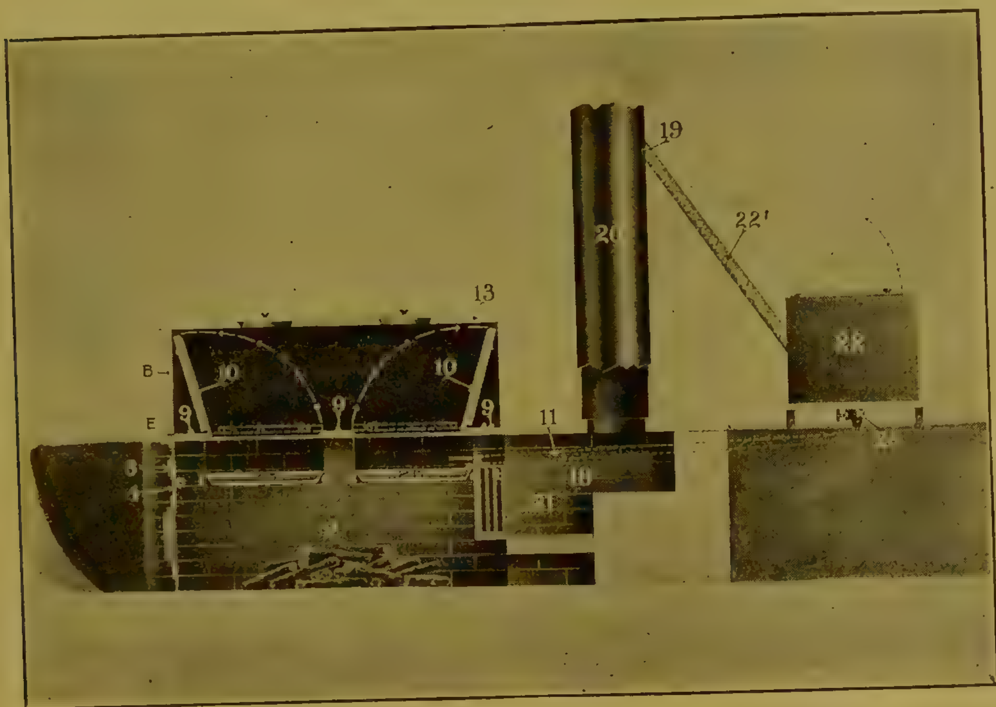


FIG. 202.—Longitudinal sectional elevation of the McCall incinerator.

can be extemporized almost anywhere. A hole is dug in a side-hill, 2 1/2 feet deep, 2 feet wide and 4 1/2 feet long, with back and floor of brick or stone laid without mortar. If the soil has sufficient consistency or if the camp is only for a day or two this lining of stone is not necessary. It is best, however, not to dispense with the stone floor, always very useful for the evaporation of urine. One foot below the top, the sides have projecting shoulders upon which rest two of the McCall excreta pans. Over all is the boxed seat with 4 holes; this can be hinged for convenience of transportation. Brush or canvas screens may be placed around so as to make the pit fly-proof. This incinerator is likely to produce unpleasant

odors when fired and should therefore be placed to the leeward of the camp. A detached can should be kept nearby to be used as urinal, and occasionally emptied upon the heated stones. If this incinerator is only for one night, the iron pans can be dispensed with and replaced by wooden pans or boards which are consumed with the excreta.

THE LEWIS AND KITCHEN INCINERATOR.—This incinerator (Figs. 204–206) consists of a horizontal cylinder about 10 feet long and 3 feet in diameter. The seats are placed on top, 4 on each side, and reached by 3 steps. The excreta fall in a pan, 4 inches deep, extending the whole length and width

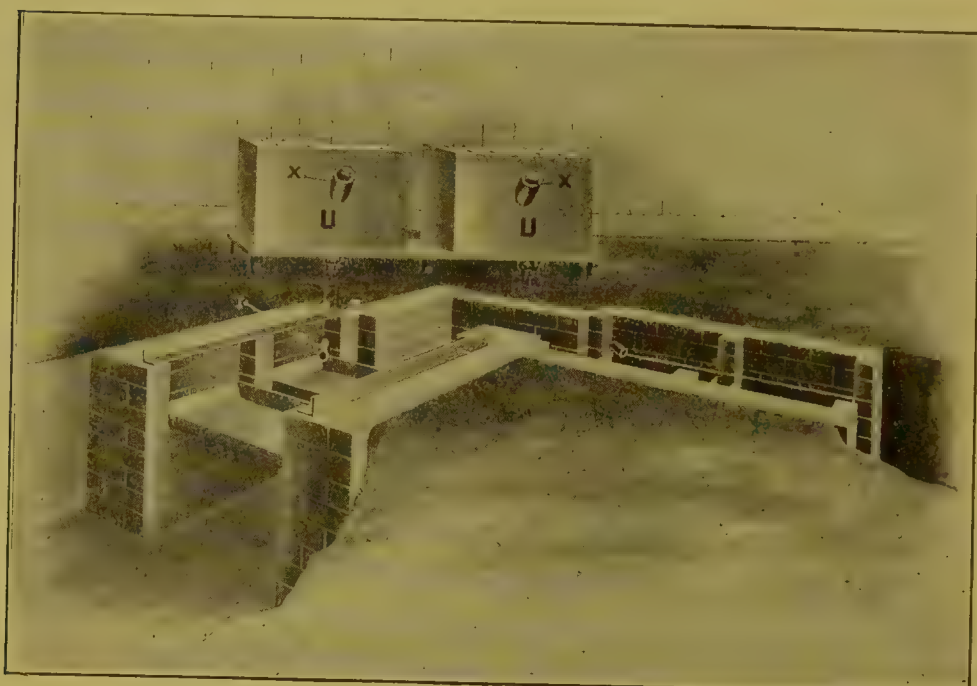


FIG. 203.—Brick-lined pit of the McCall incinerator with pans in position.

of the cylinder. One urinal is placed on each side, opposite the smoke-stack, so that the urine flows into the pan. A slow fire is kept up under the pan; the heated air above the pan, flowing through a screened opening, increases the evaporation of its fluid contents. At suitable intervals the dried excreta are pushed or drawn up upon the upper grate, directly beneath the chimney, and burned, or may be raked down and burned in the lower fire. This fire must be constantly kept up to maintain the necessary evaporation and dryness of the contents of the pan, prevent odors and escape of flies; it therefore requires unceasing attention so that it may not go out or else become so brisk as to render the seats uncomfortably

hot. It is doubtful whether this incinerator is as entirely free from odors as the other systems which are provided with auxiliary firing chambers to insure complete combustion.

The outfit, complete, weighs about 1800 pounds and, mounted on

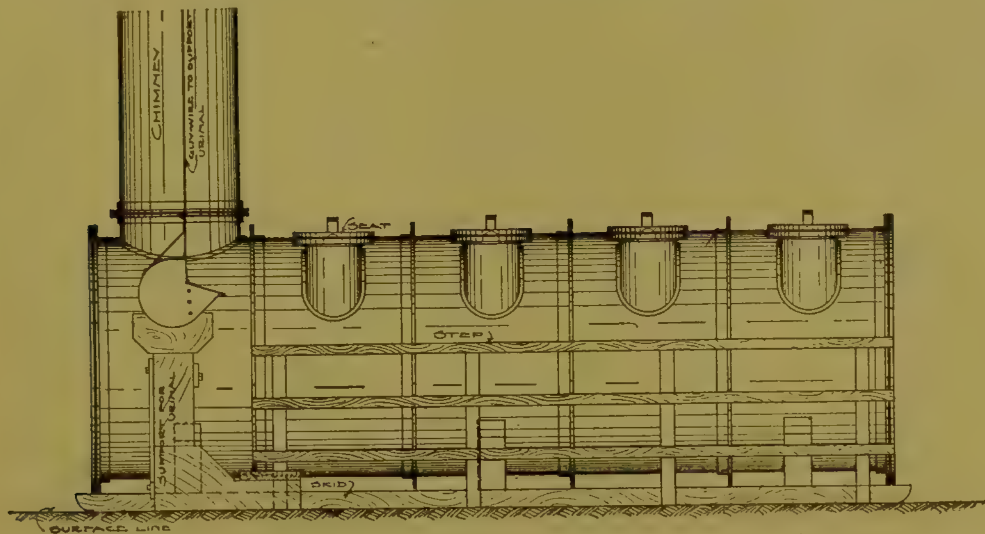


FIG. 204.—Lewis and Kitchen incinerator—side elevation.

wheels, 2500 pounds. As it cannot be taken apart, the difficulties of its transportation have to be considered.

THE CONLEY INCINERATOR.—This incinerator (Fig. 207) has some of the features of the McCall apparatus and, like it, is fired intermittently, but is

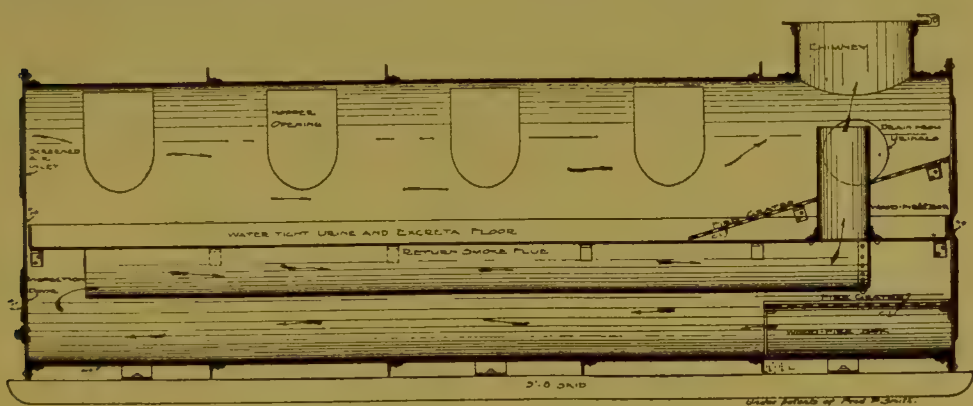


FIG. 205.—Lewis and Kitchen incinerator—longitudinal section.

more specially constructed as a combination crematory for both garbage and excreta. It consists of one or more sections connected with a common flue. Each section is 63 inches long, 27 inches wide and 27 inches deep; it has 4 seats, a urinal and an auxiliary combustion chamber. There are

2 sets of pans, the upper consisting of two longitudinal pans, and the lower consisting of five transverse ones. All these pans turn on their axis by means of a crank fitted to a projecting lug. When the fecal matter or garbage in the upper pans is dried up, it is dumped into the lower pans and from these, when desired, into the fire below. While thus burning and its combustion completed, it serves as fuel wherewith to dry and begin the incineration of the fresh material deposited in the upper pans. In the improved form of the apparatus there are 3 separate flues leading into the stack, which can be used separately or in combination, as deemed best, according to the nature of the material in the pans. The urinal, or tank for liquid wastes, has its own separate evaporating pan. A "soil pan" under the

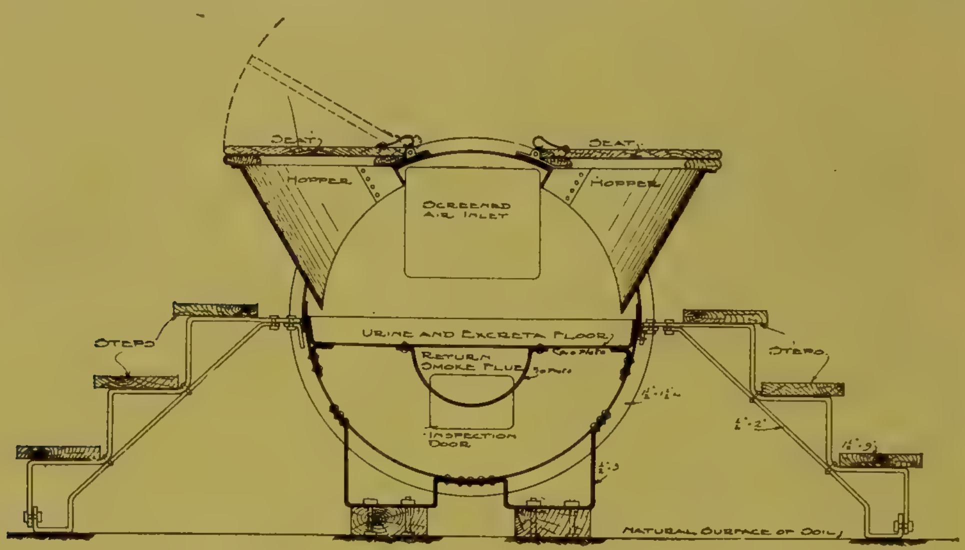


FIG. 206.—Lewis and Kitchen incinerator—cross section.

apparatus catches all dripping liquids, thus preventing soil contamination. A unit of 8 seats weighs about 1500 pounds, and can be set up, ready for use, in about 15 minutes.

Remarks.—The three incinerators described are also capable of disposing of a large proportion of the garbage of the camp, and the tendency of late has been to develop them in that direction, that is to say, make them do the work of garbage and liquid-wastes crematory as well as that of excreta incinerator. For this purpose, the Lewis and Kitchen apparatus is capable, with its slow, continuous fire, to evaporate a large amount of liquid wastes without additional fuel. A special "evaporator" constructed on the same principles, exclusively for liquids, has also been successfully tested. The Conley apparatus is likewise capable of disposing of a great deal of solid garbage.

It is quite doubtful, however, whether such combination is desirable and yields the best results. The incinerator sheds, necessarily visited by all the men and always kept scrupulously clean, should not also become garbage pens. Excreta and garbage require somewhat different treatment and can be more conveniently disposed of separately. It is not believed that such separation would require more material or the expenditure of much more fuel, for appliances constructed for one special object can accomplish it more perfectly and economically than if designed for several purposes. It is also to be borne in mind that there are camp sites

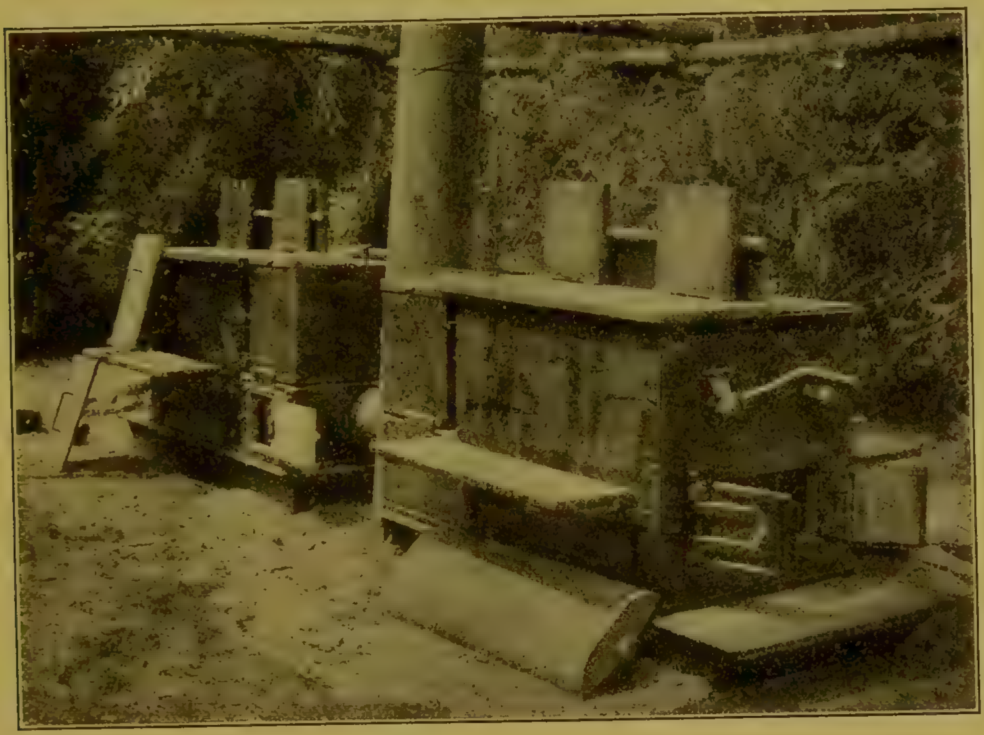


FIG. 207.—Conley field incinerator.

where only crematories are required, the excreta being already provided for by sewerage; or *vice versa*, where crematories already exist and only excreta incinerators are needed.

The Crampton Latrine.—An ingenious field latrine devised by Major Geo. S. Crampton, of the Pennsylvania National Guard, deserves a passing notice. It is circular in shape, with seats around the edge. A groove runs around the front part of the holes so as to collect the urine and separate it from the feces. The former is conveyed into a pit dug in the ground, while the latter are received in an impermeable detachable canvas bag. Whenever the bag is nearly full, it is removed, closed tight by means

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of a purse string around the edge, and carried to a crematory where bag and contents are consumed, another bag being then adjusted to the apparatus. In view of the perfection to which incinerators are soon destined to reach, this type of latrine, although possibly convenient under certain conditions, cannot be recommended for general field use.

Ambulant Incinerators.—A system of ambulant incinerators that could follow moving troops and always be available as soon as camp was reached would be ideally perfect, but is obviously impracticable; from 150 to 200 such incinerators, including 600 to 800 mules, would be required for a division, an enormous addition to the train which would seriously hamper the mobility of the command. Furthermore, as they could seldom find their respective organizations at the end of a march, until much too late to prevent the contamination of the camp, they would fail of their purpose. There are doubtless circumstances when they might be serviceable, for instance in connection with summer camps where they would enable organizations to change sites readily and safely, or for small commands marching over good roads. The Bissell incinerator which has been successfully used by the New York National Guard and the wheeled incinerator of Lewis and Kitchen, above described, are the best-known types of this system.

CHAPTER XXXIV.

DISPOSAL OF WASTES, GARBAGE AND REFUSE IN CAMP.

Conveniences for washing body and clothing must be provided as soon as practicable, especially water barrels or cans, wash tubs and hand basins. If the camp is to last more than a day or two, a place should be set apart in each company, not too near the kitchen, as a lavatory. It is not desirable to have the washing of linen and clothing done on the company grounds. One laundry shed for each battalion is sufficient and this may be located where most convenient with respect to the water-supply. Waste waters from lavatory and laundry should not be allowed to run on the ground and soak into it; they are not only unsightly and ill-smelling, but the most dangerous of all liquid wastes, being always the vehicle of

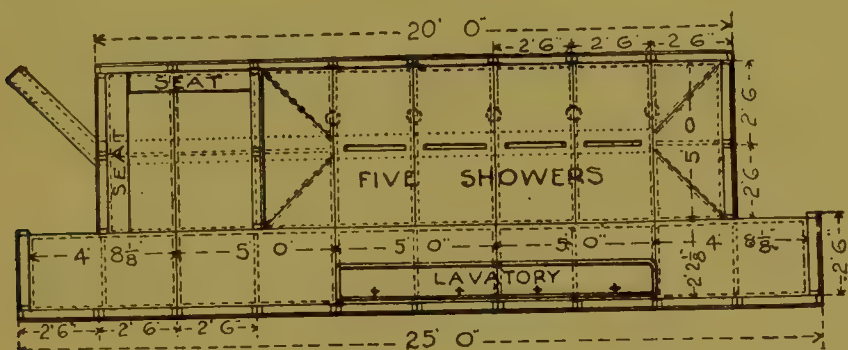

FIG. 208.—Ground plan of field lavatory. Knock-down system.

numerous germs (see p. 118). They should be emptied into suitable receptacles and carted to the rock-pile crematory or any special evaporator or incinerator used for the purpose. They may also be piped, or conveyed by a disinfected trench, to a water-course, pit or distant gully.

The regulation field lavatory for one company consists of a knock-down building 25 feet long in front and 8 feet 6 inches wide, containing 5 shower baths and one cast-iron wash sink 10 feet long (in two sections), enamelled inside, with 4 nickel-plated compression faucets (Figs. 208, 209). When intended for the use of a battalion it is extended in length so as to accommodate 4 two-section sinks and 15 showers.

This lavatory affords no facilities for the washing of clothing or linen

and is so far defective. It should contain 4 wash tubs, or else provision should be made for a battalion or regimental laundry.

The proper treatment of garbage in any place is facilitated by the separation of solids and liquids. This is readily accomplished in camp by means of a boxed screen placed in the mouth of the barrel intended for liquid slops, and only allowing liquids to drain through. This screen should have a projecting rim or flange so as to be supported by the edges of the barrel and easily removed.

All solid garbage should be burned; no other disposition is to be considered whenever fuel is available. A garbage pit is an abomination, and fire the best of all disinfectants. Liquid slops should be incinerated whenever practicable; otherwise, run into streams or poured into covered pits.

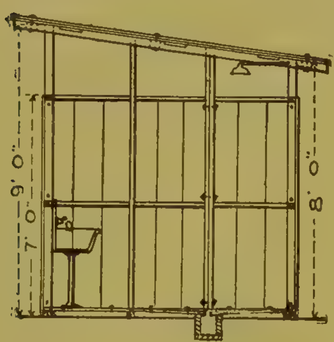

FIG. 209.—Cross section of Fig. 208.

Kitchen Pit.—The disposal of liquid wastes from the company kitchen is provided for in the Field Regulations which direct that, near the kitchen fire, a pit shall be dug for the purpose. A convenient size for it is about 6 feet in length and depth, but only 3 or 4 feet in width, so that it may be easily roofed over with cross sticks, grass and earth. At the end nearest the kitchen should be a boxed opening, preferably funnel-shaped, with screened bottom, into which all liquid wastes are thrown, the screen retaining all particles of solid garbage. When not in use, the opening should be kept covered with a lid to prevent odors and exclude flies. A ventilating shaft or pipe may be placed at the other end, but is not essential. The contents will usually seep into the subsoil and seldom overflow; if necessary they can be pumped out by the excavator wagon.

This kitchen pit when properly constructed, in porous soil, is generally satisfactory; but as it is liable to generate offensive smells it is better to dispense with it whenever a better method is available.

One or two barrels or galvanized-iron cans, with lids, should be supplied each company for its dry garbage, and an additional one for liquid wastes if a pit is not used. The iron can which serves as night urinal is kept near the latrine and utilized to collect dry refuse during the day. Two more cans may be necessary for the lavatory and laundry wastes if these are not disposed of in some other way.

Sanitary Cart.—A special sanitary iron cart is sometimes supplied by the Quartermaster's Department for the removal of garbage, liquid and

solid. But it is difficult to empty slop barrels into such a cart without spilling, while leakage is also liable to occur as it jolts on the way, so that the vicinity of kitchens as well as company streets and camp roads are exposed to fouling from these causes. It would be much better to use it exclusively for dry or nearly dry garbage, and to remove all liquid wastes by the usual excavator wagon.

Kitchen Crematory.—The company kitchen fire, if properly prepared and managed, can be made to burn much of the garbage, liquid and solid, utilizing the latter as fuel. The advice given in the "Manual for Army Cooks" is excellent: "Burn everything [in camp kitchen fire]—coffee grounds, parings, bones, meat wastes; even old tin cans, for if thrown out anywhere, even buried, they attract flies; tin cans are fly traps; burned and cleaned out by fire daily they are harmless. Fires should be cleaned of burnt refuse once a day." As a crematory, the kitchen fire is much more efficient if placed over a pit filled in with loose stones. Major Herbert A. Arnold, Surgeon N. G. Pa., recommends the following arrangement as eminently satisfactory:

"Dig a pit 60 inches long, 30 inches wide, 48 inches deep at one end and 36 inches deep at the other. Fill in loosely with stones to a height a few inches above the ground level. Bank upon all sides with sufficient excavated earth or sods to exclude surface water." The sides are then built up about 15 inches to support the grating or cross bars on which the kettles are placed, the ends being left open for draft, fuel and access to fire. The excavation provides a pit of 43 cubic feet capacity. The walling up of sides confines the fire, saves fuel and protects the legs of the cook from excessive heat. All watery materials, such as coffee grounds and dish water should be carefully poured in. The heat of the stones soon evaporates them without interfering with the fire. Tin cans and other incombustible material are removed after the fire has done its purifying work.

Such a kitchen crematory will be found very useful, even when a field cooking range is provided, unless ample provisions are otherwise made for the disposal of camp garbage.

Rock-pile Crematory.—In the absence of special appliances for the incineration of camp garbage, refuse and horse manure, solid and liquid, the simplest and most efficient device as yet found is the "rock-pile crematory" (Fig. 210) described in specifications Q. M. O. of January, 1908:

"At some convenient location selected by the military authorities a circular pit is dug three feet in depth and fifteen feet in diameter. The bottom to be covered with loose stones to the depth of fourteen or sixteen inches. On this is built a circular wall to the height of one foot above

the original ground line, and the excavated earth is packed against it clear to the top so as to provide a sloping approach and thereby prevent surface water gaining access to the pit. A pyramid of large stones, four or five feet high, occupies the center. This feature is essential to provide central draft and steady fire.

"The bottom stones receive the liquid portions of the garbage without affecting the fire, and soon evaporate and dissipate them. The solid portions are soon desiccated and become fuel. Care should be exercised to empty the garbage into and not around the crematory."

This crematory has been used repeatedly in our camps and given general satisfaction. Only one man is required for its service. At camp

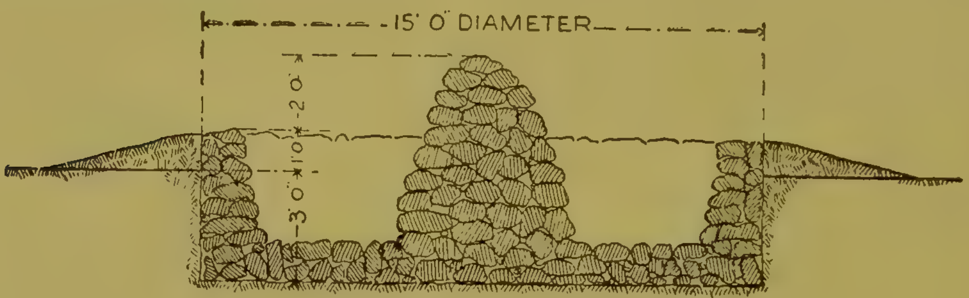

FIG. 210.—Rock pile crematory.

Captain John Smith, Jamestown Exposition, it was found that one cord of wood consumed about 4500 pounds of refuse and garbage, including all kitchen wastes and slops.

As a further improvement in the construction of the pit, it has been suggested, whenever the grounds permit, to dig it in or near a sloping bank and cut an opening about 2 feet wide in the circular wall for the easy removal of residuum and ashes.

Another and simpler device, not nearly so efficient but quite useful, is to dig two trenches a foot wide and deep, crossing each other at right angle, and to build up a chimney at the point of intersection. The garbage is fed through the chimney. The ashes must be daily raked out and a free draft maintained.

The present tendency in our camps, strongly approved by good hygiene, is not only to burn all excreta and solid garbage, but also to dispose of all liquid wastes by evaporation and incineration whenever practicable. Special appliances have been devised for the purpose and, as stated before, efforts made, more or less successfully, to utilize excreta incinerators to the same end. The effect of the complete burning of excreta and garbage

and of strict ground police was strikingly illustrated in our latest camps of instruction. Thus, at Camp Benjamin Harrison, Ind., which lasted one month of the summer of 1908, with a daily average strength of 6496 men including regulars and militia, under the sanitary supervision of Major E. L. Munson, there was not a single case of typhoid fever, while only 8 cases of diarrhea came under treatment, the daily non-effective ratio being hardly 0.5 per cent. The almost complete absence of flies was one of the striking features of the encampment.

CHAPTER XXXV.

GENERAL SANITARY RULES IN THE FIELD.

Experience has shown that in the course of a campaign, while on active duty involving much marching and fighting, soldiers are seldom sick; that scant rations, worn-out clothing, exposure to inclement weather and hardships are seldom predisposing causes of infectious diseases; that, on the contrary, hard work and plain fare are good preservatives against disease, rendering the men more resistant to germ infection. The danger comes as soon as soldiers get into permanent or semi-permanent camps and begin to make themselves comfortable, that is to say, to devote much of their time to eating, sleeping and amusing themselves, as was illustrated at Santiago de Cuba, in 1898, after the surrender of the enemy, and by the English during the Boer War, at Bloemfontein where, after an exhausting campaign quite free from sickness, they encamped to rest and recuperate.

In camps, owing to the large aggregations of men thrown into close contact, the liability to water pollution, the imperfection of sanitary conveniences and difficulty of protecting food against infection, the facilities of germ transmission are very much increased, while the effects of such transmission are momentous. The general indications, therefore, to preserve health in camp, are: avoidance of crowding and unnecessary concentrations, care in eating and drinking, adequate sanitary measures (including personal hygiene) and active exercise. These subjects have been treated in their proper chapters, but on account of their importance may now again be briefly considered in their bearing upon camp life.

1. The food should be sufficient, always wholesome, varied and well cooked. As already dwelt upon, there is more danger to be apprehended from excess than from scarcity, especially when the men are at liberty to leave the camp and patronize restaurants not under military control. During the prevalence of epidemics of typhoid fever, cholera or dysentery in the vicinity of camps, it is absolutely necessary not only that the men be prevented from eating or drinking beyond camp limits, but that all supplies from local markets be carefully inspected and their origin inquired into before being allowed in.

The men of each company should be required to eat in the mess-shelter or at some designated point, and not permitted to carry their food to their

tents or eat it at random in the company street, as this always results in pollution of the soil.

For permanent camps, the Quartermaster's Department has devised a field kitchen and a mess-shelter on the knock-down system. The kitchen (Figs. 211 and 212) consists of sections secured together with bolts and log screws; the sections of siding, roof and floor are 2 feet 6 inches in width, all siding tongued and grooved. The mess-shelter is designed to be covered by two canvas paulins, each 30 by 17 feet 4 inches, with rope for securing same at sides (Fig. 213).

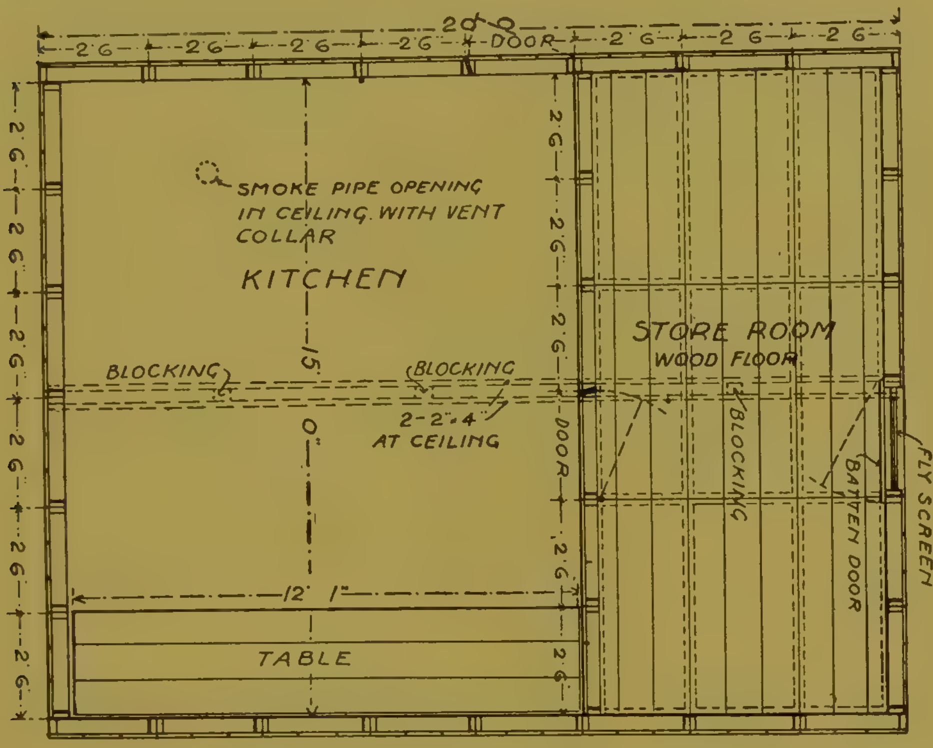

FIG. 211.—Floor plan of field kitchen. Knock-down system.

2. Every effort must be made to prevent contamination of the water-supply. As soon as there is a reasonable doubt of its purity it must be sterilized or filtered. A company will require two barrels of water daily for drinking purposes. The necessary appliances and vessels for boiling or filtering having been provided, a man should be specially detailed to attend to the supply of the company. The Forbes sterilizer and Darnall filter being easily transportable, there will be few situations when one or the other of these approved appliances cannot be made available. A reserve of pure water in the Army water-wagon, the large Forbes wagon sterilizer, or

other wheeled receptacle should always be on hand during the march and in camp.

As an army advances into the interior of an unknown or hostile country, it is not practicable to make a complete examination of all drinking waters. A rapid chemical analysis, however, such as can be made in an hour or two, may give useful indications and is often possible. Therefore, each field hospital in our service should be provided with a case con-

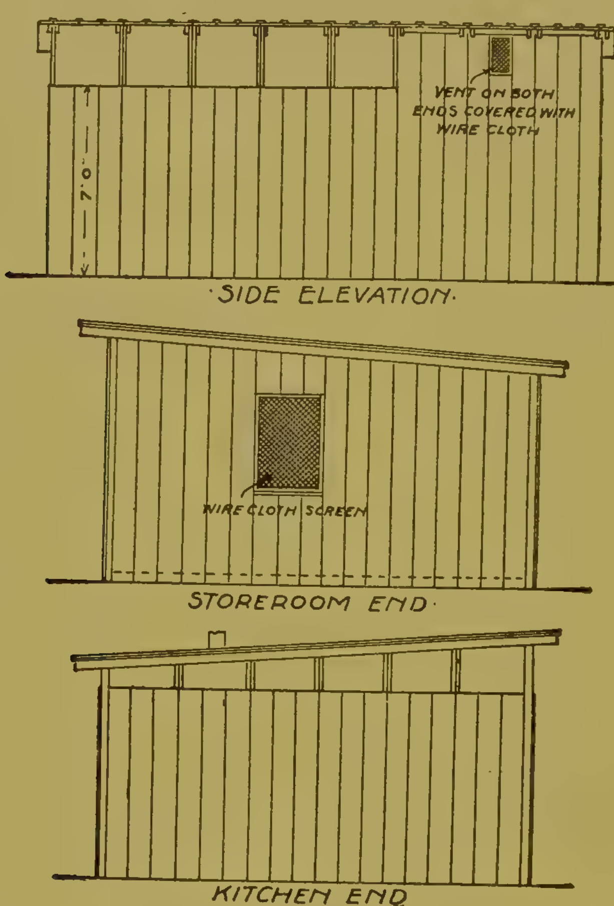

FIG. 212.—Elevations of field kitchen. Knock-down system.

taining the necessary reagents and apparatus to that end. A bacteriological examination, to be of any value, must be made in a well-equipped laboratory not liable to frequent and sudden changes, and therefore is not possible in a field hospital; but each base hospital should be furnished with such a laboratory, made portable so that it may take station outside the hospital, wherever most needed.

3. Great concentrations of troops should be avoided and camps made as small as possible, scattering brigades and divisions as much as the topog-

raphy of the country and the exigencies of the situation will permit. In the presence of the enemy, troops are necessarily strung out in thin lines, making large camps impossible. One of the secrets of the good health of the Russian and Japanese soldiers in Manchuria was the thinness of their extended lines, seldom more than a battalion or regiment being camped together.

4. Personal hygiene, that is to say, cleanliness of body and clothing, is very desirable in the field although often difficult of attainment. The men should not only bathe themselves, but also wash their linen whenever

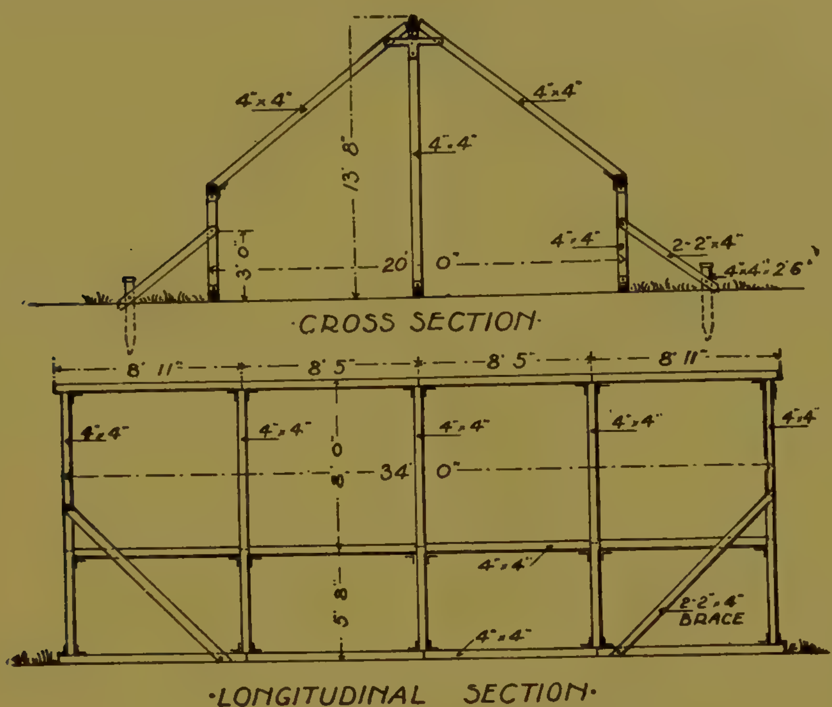

FIG. 213.—Mess shelter. Knock-down system.

the opportunity offers so that it may always be as fresh and clean as conditions permit. Then not only will they save themselves and comrades from possible contamination by germs of typhoid fever, cholera or dysentery, but, in case of a battle, they will be much less likely to suffer from wound infection, for this dangerous complication very seldom results from the slender, hard bullet of the modern rifle, but almost always from dirty skin and clothing. It is not amiss to add, in this connection, that soldiers should always go into a fight with empty bowels and bladder so that, if shot through the abdomen, the danger of extravasation and peritonitis be reduced to a minimum. The hands are probably the most

dangerous agent of disease transmission in camp and therefore must be frequently washed.

5. As fully explained under *Latrines*, the greatest danger to which troops in camps are exposed is from infected human excreta; their proper disposal must always be one of the chief preoccupations of sanitary officers. Whenever a case of infectious disease is detected in a company or regiment, the most effective course to pursue is to remove the patient promptly to a field or base hospital, thus precluding, in a large measure, the possibility of transmission to other men. By vigilantly attending to this prompt segregation of first cases and, at the same time, keeping under observation the men who have been in contact with them, no epidemic or serious outbreak of any camp disease is likely to occur.

6. Bearing in mind the agency of flies and mosquitoes in the conveyance of infection, it will be well, so far as means permit, to screen with wire netting all the buildings, sheds and tents which need most protection, namely, mess-sheds, kitchens, latrines and lavatories. It is especially necessary that the food, while being prepared and consumed, be suitably guarded. By the use of the mosquito-bar, malarial fever, formerly the most prevalent of camp diseases, is now the most preventable and the least dangerous; the mosquito-bar, therefore, has become part of the equipment of the soldier, as much so as his blanket and first-aid packet, and its persistent use in camp, wherever mosquitoes are present, must be insisted upon. When these insects are troublesome, a head-net also becomes absolutely necessary, especially for men on guard. In the Russo-Japanese War such a net was issued to each Japanese soldier with his summer uniform; it was collapsible and carried tied to the belt.

7. The cleaning, policing and disinfection of the camp grounds should be the first daily duty of the troops after breakfast. Every part should be carefully inspected and receive the treatment it requires. All organic dust, but especially decaying animal and vegetable matter, must be swept or scraped up and, with all other garbage and refuse, including tin cans, carted to the crematory. Wherever the soil has been fouled by urine or slops, it should be sprinkled over with lime or clean earth. Ditches must be cleaned and all stagnant-water puddles drained or filled up. Disease germs on or in soil which is pounded into dust by the tramp of men and animals are, of course, easily blown about so that a neglected camp is a menace not only to itself, but to all its neighbors. A camp should be kept as scrupulously clean as military exigencies permit, but the custom, much too common, to sweep the entire grounds every morning and raise clouds of dust is distinctly objectionable and insanitary; many

of the germs are simply scattered over a larger area, not removed. Dirt can be picked up, raked or scraped, or swept in places, after sprinkling, but indiscriminate sweeping should not be tolerated in camps any more than in city streets.

Manure breeds flies, renders the soil a better medium for the growth of micro-organisms and is otherwise objectionable. Therefore stable-sheds and picket-lines must receive special attention. They should preferably be located on porous, absorbent soil so that the urine may quickly disappear. As little hay and straw should be allowed to litter the ground as possible so as to reduce the amount of manure to a minimum. If the manure is not utilized by farmers, it is best to burn it. The picket-lines and stable-sheds should be carefully raked, and all dung scraped up and cremated. As often as may be desirable, they are covered with a thin layer of clean fresh soil or sprinkled with lime.

8. How often should a camp be moved; that is to say, when does a camp, from mere occupancy, become so fouled and infected as to require its abandonment? This depends largely upon the manner and extent of its sanitation. A camp may be so well provided with conveniences, so well policed and safeguarded against the invasion and propagation of infectious diseases as to be fully as healthy as a properly governed post or cantonment; in such case there is no reason for change of site. Thus during our occupation of Cuba, after the Spanish War of 1898, camps were kept on the same sites for more than a year with marked benefit to the health of the troops, notwithstanding the depressing effect of a tropical climate. The rule is that, with a good site and good sanitation, a camp can be occupied indefinitely.

There is a change, however, within the camp, which is always practicable and beneficial. Even with good police the soil areas covered by the tents are likely to remain damp and to become contaminated by various kinds of organic matter. Therefore it is well, now and then, to shift the tents to the immediately adjoining grounds, while preserving the relative arrangement of the company street, so that the uncovered soil may be exposed to air and sun; at the end of a week or two they are replaced upon the original sites.

The sanitary reasons requiring the removal of permanent camps are the following: When, through bad sanitation, especially bad management of latrines, the soil has become polluted with fecal matter and urine, or impregnated with decayed organic matter, and therefore a dangerous medium for the multiplication of disease germs; when the water-supply is infected and means of purifying it are inadequate; when the site is so

situated that it receives the drainage of camps on higher grounds; when, through irremediable causes, flies, mosquitoes, or other insects are very troublesome; finally, when, another good site being available, it is deemed desirable to give the troops a change of surroundings and active occupation for awhile.

9. Knowing what to do to prevent disease, we may ask by what agency it is to be done and under whose direction. Until recent years all sanitary work in our camps was done under the immediate supervision of the Quartermaster's Department. Medical officers were simply permitted to make recommendations which were more or less heeded. There was, therefore, a divided responsibility which bred indifference and prevented the attainment of the best results. It has at last been realized that military hygiene is specialized knowledge and that medical officers alone are fitted to direct and supervise its application. Hence came the present sanitary organization of our camps of instruction whereby the whole business of sanitation, conception and execution, is intrusted to the Medical Department. The Quartermaster's Department is simply called upon to furnish the material and hire the necessary civilian laborers. It seems quite probable that a further advance would be made, and the best interest of the service subserved, were the Medical Department required to supply and control all sanitary material and personnel.

It has been found that the best sanitary service is obtained by the organization of regimental sanitary squads, each consisting of hospital corps men and hired laborers, under the control of one of the regimental medical officers. Where laborers cannot be procured, special details must be made from the companies. The regimental sanitary officers are under the direction of the sanitary inspector of the division.

CHAPTER XXXVI.

SERVICE IN WARM CLIMATES.

Including colonies, the territory of the United States extends from northern Alaska, near the 70° latitude, to the southern Philippine Islands, only some five degrees north of the equator. Within these limits is the greatest variation of climatic conditions, from a mean annual temperature of about 83° F. down to one well below the freezing-point, and from vapor-saturated sea islands to deserts as arid as those of Africa. It must be borne in mind that extremes of temperature are not only found in the Philippine Islands and Alaska but exist as well within the United States. Thus, Manila has a mean annual temperature of 80° F., while the mean of its hottest month, May, is only 83.5°, and the maximum of any day during this month never reaches 100°. With this may be compared the summer means (May to September inclusive) of Fort Yuma, Ariz., 86.26°, and Laredo, Texas, 84.10°. Furthermore, a maximum temperature exceeding 100° F. may be expected, with few exceptions, in any city of the United States south of New York and Chicago; while, in the southwest, a maximum of 105° to 115° is not rare. However, the combination of high temperature and great humidity only exists in our South Atlantic and Gulf States, and these may be truly said to have a tropical summer climate, a climate indeed often more trying, from the absence of air movements, than that of Manila, Havana or Porto Rico always fanned by the trade-winds. On the other hand, parts of the United States suffer from extreme cold during the winter, the thermometer falling to —40°, or even lower, in some of the northern States. This extreme variation of temperature, from torrid heat to Arctic cold is the most striking feature of the continental climate of the United States. Thus, the writer observed an annual variation of 144° F. at Pembina, N. D. (49° lat.), namely, from 96° in July to —48° in January. But even those States with the highest summer temperature have a comparatively cold winter, often down to frost, which partly neutralizes the effects of the summer heat and prevents the deteriorating influence on the human system often seen in true tropical regions.

The climatic conditions characteristic of the tropics are constant high temperature and relative humidity, bright luminosity and great electric

tension. In what manner these conditions affect the body is still imperfectly understood.

The perspiration is greatly increased in order that a more active evaporation may maintain the body temperature within physiological limits. The result is also a diminution of urine and of the digestive fluids. The urea is lessened, but this is mostly, if not entirely, from lessened food.

In spite of the more abundant perspiration, the skin evaporation seems unable to prevent a rise of body temperature in new-comers, amounting to half a degree or more; but gradually the system adjusts itself to its new conditions so that, in a year or two, the temperature is again normal.

Under the direct rays of the hot sun the skin gets dry; this, at first, is the result of the more rapid evaporation of the sweat, but if the exposure continues, the dryness may become pathological, the result of checked perspiration due to the effect of the actinic rays upon the cutaneous nerves, one of the symptoms of heatstroke.

According to the observations of Wickline and other members of the Medical Corps, United States Army, made on 104 American officers and enlisted men, in the Philippines (Mil. Surgeon, October, 1908), the composition of the blood undergoes notable changes. In 86 per cent. of all men examined, the hemoglobin is decreased from 94 per cent. at the first examination to 83 per cent. at the last, nearly 2 years later. The erythrocyte count, on the contrary, is increased up to an average of 5,640,000. The most remarkable change was found to occur in the differential leukocyte count, consisting in the continuous decrease of polymorphonuclears, down to an average of 54 per cent., with a relative increase in the lymphocytes. This decrease is rendered significant in view of Cabot's remark: "It would appear that the degree of health in persons not organically diseased, might perhaps prove to vary directly with the percentage of polymorphonuclear cells in the blood."

The number of respirations, in Wickline's observations, shows an increase, with an average of 19.6 per minute, a result materially differing from that of Rattray who records that the respirations are lessened in number and in depth. The pulse rate is not reported, but it may be assumed that, if changed at all, it is slightly increased in harmony with that of respiration.

The expansion or rarefaction of the air caused by the heat in the tropics, reduces the amount of oxygen contained in it to an extent of about 3 per cent. Since the hemoglobin of the blood is the oxygen-carrier to the tissues, its decrease further reduces the amount of oxygen which becomes available for the system, and the capacity of the lungs to eliminate car-

bon. To make up to a great extent for this deficiency, nature, as stated above, increases the number of red blood-cells, together with the number of respirations, as it does in people residing at high altitudes. The liver and kidneys seem also to make up, in some measure, for the decreased pulmonary excretion by eliminating more carbon in forms requiring less oxygen for their production.

Of 101 men examined by Wickline, it was found that, at the end of about 2 years, 82 had lost an average of 8.1 pounds, 4 showed no change while 15 showed an average gain of 6 pounds.

The effect of a tropical climate upon the nervous system is noticeable in a large proportion of people, causing general depression and loss of vital energy, with tendency to neurasthenia and mental irritability. There is no evidence that, so far as Americans are concerned, blonds are oftener or more seriously affected than brunettes.

To sum up, it may be stated as an accepted fact that in our colonies, as in other tropical countries, from climatic conditions alone, irrespective of endemic disease, the endurance of the North American is put to a severer test, while he is incapable of the same mental and muscular exertion.

Soldiers sent to the tropics should be picked men, in good physical condition and not less than 22 years old; younger men have but little power of endurance and are more susceptible to infectious diseases. They should arrive at the beginning of the dry and cold season, usually November or December, so that they may partly adapt themselves to their new surroundings before the advent of summer. The sanitary conditions under which our soldiers in the colonies are obliged to live have very much improved of late years, and their power of resistance to the depressing effects of the climate have correspondingly increased. The length of time they can serve in the tropics without detriment to body and mind cannot be definitely stated, depending as it does upon many variable factors, but there is no doubt that, under ordinary circumstances, they could remain at least 3 or 4 years with entire impunity. A large proportion of the English troops in India remain from 8 to 12 years, but it must be noted that much of their time is spent at posts located in mountainous regions, and therefore in a subtropical if not temperate climate. Their statistics show that, within certain limits, the longer a soldier remains, the less susceptible he grows to his pathogenic surroundings, so that he is able to render better service the third and fourth years than the first and second; in other words, in healthy men of good habits a marked degree of physiological acclimatation takes place. The War Department, in reducing the term of service

of our soldiers in the Philippine Islands to two years, has doubtless been inspired by other considerations than the mere economic aspect of the subject. However, under the best possible conditions, it is obvious that white troops, sent from the United States to the colonies, not only require very expensive care but will never acquire the natural resistance which is enjoyed by the natives. The latter, as the experience of all countries has shown, if well trained and well officered, will make excellent and reliable troops with much less effort and cost. Therefore, speaking from the viewpoint of hygiene, the easiest way to reduce the mortality rates for disease in our colonies would be to replace the white troops serving therein, as far as possible, by native and colored troops.

FOOD.—The food suitable for warm countries has already been discussed (page 218). There can be no doubt as to the principle that, to preserve his health and yield his greatest efficiency in a tropical climate, the soldier must reduce his daily ration; but this principle is very imperfectly understood and, in practice, carelessly observed. Eating is to a large extent a matter of habit, and men will consume the same quantity of food they have been accustomed to, regardless of climate, unless their attention is especially called to the danger of such indulgence.

Not only the system does not require so much food, but the amount of muscular exercise being necessarily reduced, less of it can be metabolized and excreted, so that, should the same quantity be ingested, the system gets clogged, while an unusual amount of physiological work is thrown upon the liver and kidneys in their efforts to get rid of all useless waste products. A condition of physiological hyperemia is brought about which is the first stage of the "tropical liver"; this condition soon passes into one of static congestion with diminished functional activity. In the first stage, there is usually a copious flow of bile with perhaps bilious diarrhea, but in that of congestion there is impaired hepatic action and those digestive disturbances which result from lack of healthy bile. One step further and congestion may pass into actual inflammation, or hepatitis, with enlargement of the organ, fever, pain and tenderness on pressure.

The reduction of food should be chiefly in fats and meats whose waste products throw most work upon the already strained eliminative organs. Nitrogenous food is, of course, everywhere necessary, but, in the tropics, it should be chiefly supplied by fish, poultry, eggs, cereals rich in gluten, and the pulses (beans, peas and lentils, indigenous and introduced); the bulk of the food should always consist of starchy cereals, fresh vegetables and fruits.

In India, sulphur fumes are used quite successfully to prevent the rapid decomposition of meats and render them more tender.

Beverages.—Concerning beverages, it is well to bear in mind the French axiom that, in the tropics: "To seek pure water and shun alcoholic drinks is the beginning of wisdom." No water should be used which is not known to be wholesome, or has not been purified. More of it is necessary in warm than in temperate regions so as to provide for the increased perspiration. The best time to take it is between meals, or in the morning and evening. To drink much and often is a bad habit, disturbing the digestive functions and weakening the power of endurance. Water should be cooled with ice so as to be palatable and refreshing, but ice-cold water is liable to produce gastric and intestinal troubles and always dangerous in the tropics. In the absence of ice, water can be cooled by the usual native methods, namely, by letting it filter or ooze through a porous earthen jar or olla, the evaporation of the fluid on the surface abstracting the heat of the jar and contents; or a metal receptacle can be used, with covering of felt or flannel occasionally wetted, like the soldier's canteen. The process of evaporation and cooling is much more rapid if the receptacle be hung in a draft, overnight. Incidentally, the olla always clarifies the water and may also materially purify it if brushed inside and outside and sterilized once a week.

Alcoholic drinks, in the tropics, should be entirely discarded or else used with the greatest discretion. They throw more work on the liver and kidneys already overtaxed, and lower still further the nervous energy already depressed. "Alcohol is a predisposing cause to all endemic diseases; on this point all authors in exotic pathology are unanimous; in epidemics, the intemperate are the first and surest victims" (Treille). There is no objection to tea and coffee; they will furnish all the stimulation that may be needed under most circumstances. To relieve fatigue and quench thirst, on a hot day, Englishmen, Frenchmen and Russians rely mostly on tea. Coffee and tea are made with boiled water and have therefore the merit of being sterilized drinks. For this purpose, tea will admit of a much higher degree of dilution than coffee (see *Coffee* and *Tea*).

SOLAR HEAT AND LIGHT.

It will be useful to remember that the solar spectrum consists of a series of colors, ordinarily described as red, orange, yellow, green, blue, indigo and violet. These colors result from the dispersion of the rays of different wave-lengths, the wave-length of the extreme red at one end of the spectrum being about twice that of the extreme violet at the other end. Be-

yond the visible spectrum, however, there is also an invisible part below the red, called the infra-red region with much greater wave-length, and another beyond the violet, called the ultra-violet with shortest wave-length. The spectrum has been divided into three parts formed respectively by the invisible heat rays, the luminous rays and the chemical or actinic rays. This division, however, is more or less arbitrary for all rays of the spectrum are heat rays and possess more or less chemical power. It is true, nevertheless, that chemical changes are most stimulated by the violet and ultra-violet rays, and least by the red and orange.

Of late years, it has been more clearly realized that the solar rays affect animals and plants in their threefold power: by heat, light and actinic or chemical action. These effects are probably never separated but may be combined in greatly varying proportion. That heat alone cannot produce all of the symptoms of insolation is made evident by noting the effects of simple artificial heat in rolling-mills and the fire-rooms of ships where the temperature not infrequently rises to 200° F. Such heat is borne, for short periods of time, without injury. On the other hand, active work in the open sunlight at a temperature exceeding 100° is perilous for the white man; the colored man endures it better, although, on the other hand, he is less resistant to the effects of extreme artificial heat.

Of the nature of the chemical action of sunrays upon man but little definite is known. It is apparently directly proportional to luminosity, but also greatly influenced by heat; in fact it is seldom noticeable except when accompanied by a certain degree of heat, so that only in warm countries does it become sufficiently marked to be injurious. On the summit of high mountains, solar radiation and luminosity are greater (see p. 300), and the intensity of chemical action is said to be much increased (Hann); but, provided the head be kept well protected, the cold air and perhaps also the active evaporation from the skin prevent any dangerous effect of insolation.

It is to the constant stimulus of sunlight that are attributed the quick fancy, vivacity of gesture and animated language of the people of southern countries. But light, like heat, is often excessive and must be guarded against. A strong light reflected from a white bright surface soon becomes painful and, if continued, may produce headache, blurred vision and vertigo; in other words, a lightstroke.

According to Woddruff,* the stimulating effect of sunlight is due to its actinic rays; pleasant and helpful when moderate, but harmful, depressing

*Effects of tropical light on white men. Charles E. Woodruff, Medical Corps, U. S. A., 1905.

and overwhelming when excessive. That learned author considers the bright sunlight of the tropics the chief enemy of the white man and advises that all possible means be employed to exclude it. The well-known disinfecting effect of sunlight, that is, its destructive action upon pathogenic bacteria, the decomposition of the atmospheric carbon dioxid under its influence by plants containing chlorophyll, its effect in tanning, inflaming and blistering the human skin, as well as in the process of bleaching fabrics, are so many instances of chemical action. Nature protects the natives of the tropics and acclimated colonists by pigmenting their skin, proportioning the darkness of the pigment to the intensity of the light so as to shut out most of the injurious actinic rays. The white man living in the tropics should therefore take a hint from nature and protect himself, so far as he can, by lining his hat and coat with a fabric of the color that best excludes the objectionable rays. Quite a number of well-authenticated cases are on record of officers unable to do field duty without acute headache and great discomfort until they had recourse to that simple expedient.

What color is most effective to that end? Which shade of human pigment should we approximate? The copper of the American Indian, the bronze of the Hindoo, the yellow of the Chinese or the black of the negro? It appears that the nearer we approach to the equator the darker becomes the pigment, and that black, therefore, should be preferred. It is known that red and orange filter out more of the actinic rays than any other color of the solar spectrum and, for that reason, are used by photographers in the window of their dark rooms. In following out this indication, undue prominence has been given these two colors by tropical hygienists, while the claim of the plain black, which for obvious reasons cannot be used by photographers, has been overlooked. If small squares of silk, of exactly the same texture and thickness but of the different colors of the spectrum (as near as they can be approximated in dry-goods stores), with black and white added, are placed on very sensitive photographic bromide paper and exposed an instant to the light, it will be found (Fig. 214) that *black excludes the chemical rays more completely than any color*, and that the colors exclude them in the following order: red, orange, green, blue, indigo, violet, yellow, white. In studying Fig. 214, it is interesting to note the selvage edge which, in all the samples, is on the right side. This edge is not appreciably thicker than other parts of the fabric but more closely woven, therefore more opaque. The result is seen in the fact that this edge is white, or nearly so, in all the colors except yellow, violet and white. The effect of color, however, is obvious in the selvage of the

black and blue squares where a white line becomes black, and in that of the yellow square where a reddish line becomes nearly white.

From these and similar observations, it is deduced that the non-actinic value of a textile fabric depends more or less upon its color, but more upon its opacity; that any fabric which excludes light also shuts out

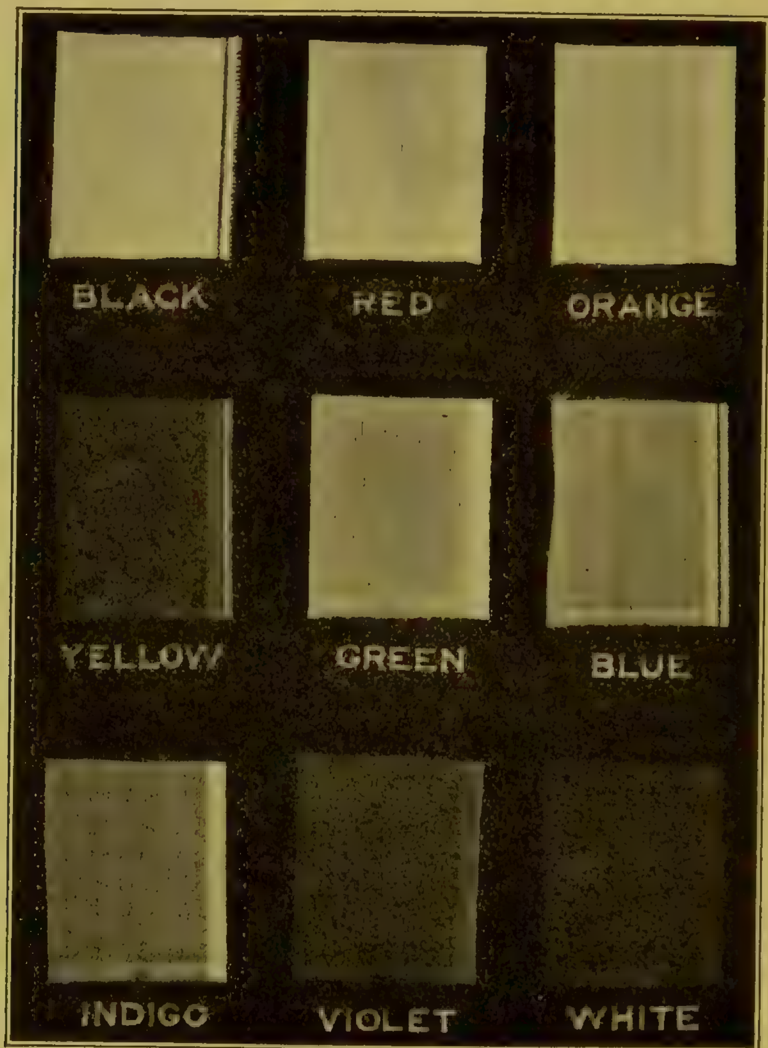

FIG. 214.—Photograph showing the anti-actinic value of colors, including white and black.

actinic rays, and that this result is most surely and easily obtained, the thickness of the cloth remaining the same, with black than red or orange; black is also more easily procured and less conspicuous; therefore it should be the color of the fabric used to line the head-dress and part of the coat, or for the undershirt. Silk being light and a poor heat conductor

may be particularly recommended as the best fabric for the purpose (see p. 235).

In case of photophobia, or whenever the eyes are unpleasantly affected by light, Gould has found that amber-colored glasses are best, admitting enough of the more luminous rays (yellow) and excluding those which are injurious to the retina.

Sunstroke.

Under this comprehensive popular name are included three separable conditions, although the first two are not always clearly differentiated: insolation, heatstroke and heat exhaustion, and the soldier may suffer from one or another of a combination of them.

Insolation (siriasis, sunstroke proper), the most dangerous of them, results from exposure to the direct rays of the sun, and may be ascribed to the violent action of the ultra-violet (actinic) rays at a high temperature. It is always manifested by rapid and severe symptoms, such as intense headache, a quick, full pulse and hot, dry skin, suggesting meningeal congestion or inflammation; or, in grave cases, by sudden unconsciousness, apparently caused by paralysis of the heart or of respiration. It may be seen on the march but is more likely to occur during the stress of battle, under a blazing sun, when the head is imperfectly protected.

Heat-stroke, also called thermic fever, is of common occurrence in this country wherever great heat and a high degree of humidity are combined, as in the eastern and southern States. Intemperance, fatigue, bad ventilation, malaria and all other depressing conditions are predisposing influences. Its etiology is still uncertain; heat is probably the chief factor, with more or less actinic effect. From the fact that direct exposure to the sun is not necessary for its production, and the peculiarities of its distribution and prevalence, Sambon and Manson are inclined to consider it a germ disease. The symptoms are, in the first stage: fatigue, pains in the limbs, drowsiness, headache, vertigo, mental confusion, intolerance of light, contracted pupils, suffused eyes and face, nausea and vomiting, hot, dry skin (rarely moist) and quick pulse. They are soon succeeded by high fever and burning skin, the temperature rising to 108 to 109° F. (H. C. Wood), an exceedingly rapid pulse, later becoming irregular and intermittent, labored breathing, convulsions and complete unconsciousness. The treatment consists in taking the patient to a cool, shady, well-ventilated place, removing his clothing and reducing his temperature by the application of cold or iced water. The administration of digitalis and

strychnine will generally be indicated, and artificial respiration may be necessary.

It must be borne in mind that some of the pathological effects of sunstroke are more or less permanent, that the patient seldom completely recovers and always remains more susceptible to a subsequent attack; hence the saying, in some of the British colonies, that "once sunstruck always sunstruck." It seems an admitted fact that man does not become habituated to hot solar rays, so as to be immune to their effects, any more than he becomes habituated to the contact of fire. The native of hot countries, although endowed by nature with a dense and very black (non-actinic) head of hair, generally protects himself with ample hat or thick turban. The present custom or fashion of riding and indulging in all sorts of out-door sports, bare-headed, during the hot summer days, is not approved by the best judgment of hygienists and may certainly result in serious harm.

Heat exhaustion is a state of syncope or faintness resulting from high atmospheric temperature combined with fatigue or privation, and often induced by alcoholic excess. The patient is pale, with cold skin and subnormal temperature; the pulse is small and soft, and the breathing shallow; the pupils are generally dilated. There is seldom complete unconsciousness. He should be laid on his back in a cool, shady place, his clothing loosened and a little water dashed on his face and chest. Gentle stimulation is indicated; spirits of ammonia may be held to the nose or given by the mouth; whiskey, suitably diluted, may likewise be given by the mouth or else, in case of unconsciousness, injected into the rectum.

CLOTHING.

The general subject of clothing has already been considered, and so far as it relates to the tropics can be summed up in a few words. The underclothing should consist of a light wool-knit or cotton-knit loose undershirt, jean drawers and thin woolen or cotton stockings. For those who can afford it, a gauze of wool and silk makes the ideal material for undergarments. The outer clothing should be khaki, white cotton or linen, loosely fitted. When the coat is not worn, the olive-drab flannel shirt is substituted. The best head-gear is a well-constructed, black-lined helmet; but, for the American soldier, the campaign hat is more serviceable, provided it is lined with black or orange, well ventilated and waterproofed. The hair is a natural protection against the sun and should not be cut too short.

A flannel abdominal band, worn at night, is often very useful in the

tropics, especially in the hot season. As one lies in bed, uncovered and perspiring, the abdomen, which is the most sensitive part of the body, will be chilled before any other part feels the change of temperature, and digestive or intestinal troubles may result in susceptible people. The abdominal band is never useful during the day, and seldom at night when the cold is so marked as to require one or two blankets over the sleeper.

SHELTER.

In the erection of quarters or barracks in the tropics, the objects to be aimed at, from the hygienic viewpoint, are to exclude heat and excessive light, and provide ample ventilation. Greater air space and movement should be provided than in northern climates, and this can be done chiefly by raising the ceiling to a height of 13 or 14 feet and extending the windows downward to near the floor and upward to near the ceiling. The barracks, and as many of the other buildings as possible, should be so oriented as to face north, therefore with the long axis running east and west. This however may be modified in accordance with prevailing

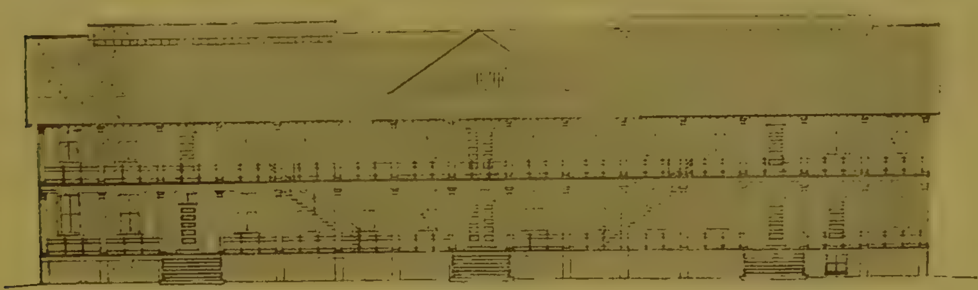

FIG. 215.—U. S. barrack in the tropics. (*Honolulu.*)

breezes; thus to get the benefit of the N. E. trade-winds, the axis should preferably run W. N. W. to E. S. E. The barracks should be of two stories, each story with a broad veranda going all round and protected by Venetian blinds on the sunny sides. The upper story is to be used for dormitories, and above it should be a spacious, well-ventilated attic. The best building material is iron, brick and stone; a thick wall with a course of perforated bricks permitting a free air circulation is nearly ideal. The roof should be of tile or concrete, and the floors of cement, vitrified brick or tile. The color of the outside paint or kalsomining must not be white, which injuriously dazzles the eye, but a soft light tint of gray, yellow, pink or blue.

The effect of water evaporation in cooling the air of habitations is

seldom fully appreciated and utilized; thus the temperature of a room 70 feet long by 30 feet wide, sprinkled with a gallon of water, will speedily fall from 80° to 70° F. Verandas should be freely sprinkled. The East Indian method of suspending mats in doorways on the windward side, and keeping them constantly wet is also very efficient, provided there is a breeze.

The mosquito being always a dangerous enemy in warm countries, every effort must be made to exclude it; in a malarial locality all quarters

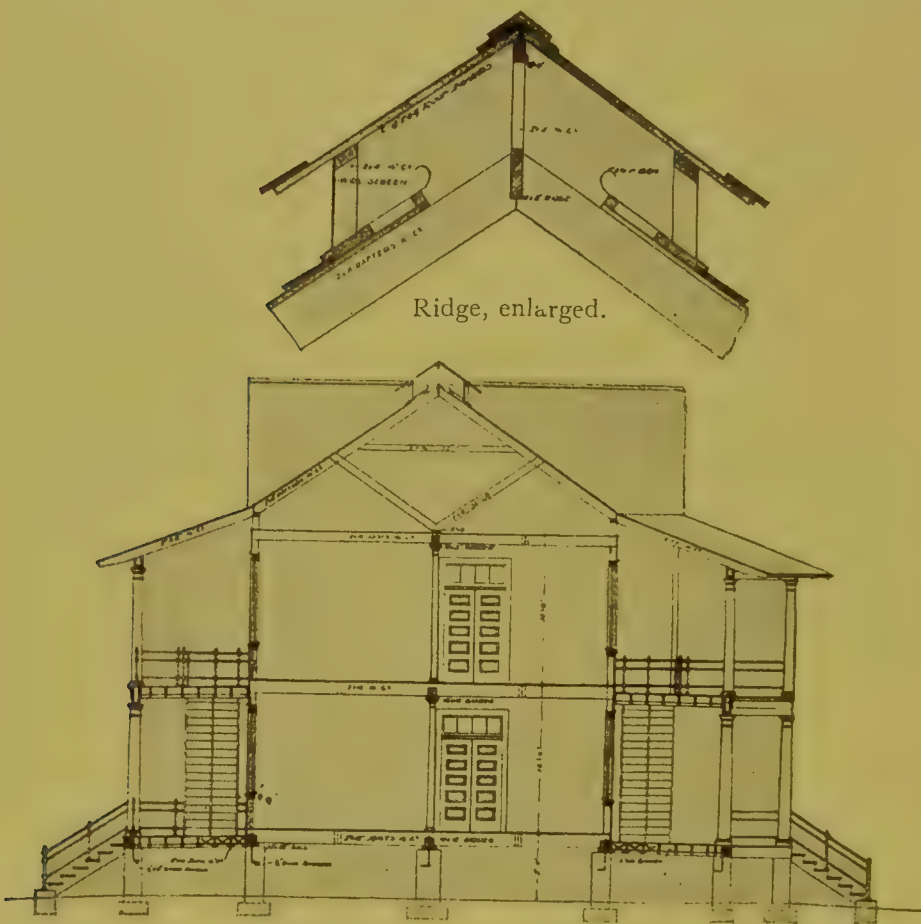

FIG. 216.—Cross section of Fig. 215.

should be completely screened, and originally planned with a view to the possibility of this effective screening. But, under all circumstances, at least the kitchen and mess-room should be entirely protected by wire netting, so as to keep out not only mosquitoes but also flies and other insects.

In cantonments, 1-story frame buildings well raised above the ground,

with suitable verandas, large windows, ridge ventilation and tiled roof (or double roof of corrugated iron) are very satisfactory, but it will often be found advantageous to utilize native material and labor and erect structures of bamboo and thatch which can be made fairly comfortable and sanitary.

The use of tents, in warm climates, should be avoided as much as possible, as it is always difficult to keep them reasonably cool, dry and otherwise comfortable. Whenever used, each should be covered with its fly set at an interval of about a foot from the roof. In a camp of some duration, the tents should be shaded, whenever possible, with a roof of brush, straw or grass. An excellent method of cooling them is to dash water against the walls and over the roof, but not enough to close the pores of the canvas. The best tents for hot weather are the tropical hospital tent and the tropical wall tent described under *Camps* (p. 364, 368). For the sick, a black, dark blue or dark red lining, to exclude actinic rays, will add to the comfort of the hospital tent; if more light is desired this lining can be covered with pale yellow chintz. The conical tent is entirely unfitted for hot countries; it is more stable but, on account of the low roof and lack of fly, always several degrees warmer than the hospital tent.

GENERAL DIRECTIONS.

Physical exercise, in the tropics, is highly useful and should never be neglected, but must be performed at the proper time. Drills and all military exercises should not be permitted, as a rule, whenever the temperature exceeds 85° F.; with a cooling breeze this limit might be raised to 90°; therefore the best time for them will be in the early morning before 8 o'clock, or in the evening after 5 o'clock. All work not absolutely necessary should be suspended between 11 A. M. and 4 P. M., the hours of siesta. During these hours it is not necessary that the men should sleep, but desirable that they should enjoy complete mental and physical relaxation. Marching should begin at dawn, or even before, and stop at or before 9 o'clock, to be resumed, if necessary, after 5 P. M. To break the usual night rest is always to be deprecated, but, whenever optional, it is less exhausting and greatly preferable to do so than to march during the day under a torrid sun, provided time is given to make up sleep at the first opportunity. There is a time of day when the sun is exceedingly trying, that is when approaching the horizon, before setting; then its horizontal rays strike the face, eyes and temples, parts well protected at other times, with great actinic intensity. If the command is not yet in

camp, and the direction of the march is westward, it will be wise, circumstances permitting, to halt until after sunset. The step should be an easy route step, in open order and with load as light as possible. The men should never drink on the march, except at the halts, after cooling off, and then very moderately.

In warm countries the loss of heat by radiation is generally very rapid after sunset, causing a sudden fall of temperature and chilling sensation. The same sudden change may take place after a rain. This is to be guarded against by buttoning up the shirt and blouse, adding or changing garments, especially by those susceptible to malarial or diarrheal diseases. The experienced soldier nerver parts with his blanket, however irksome it may be to carry during the day. The effect of altitude on the tropical climate is also very remarkable, a rise of 1,000 feet being equivalent to a change of 6° to 10° latitude further north, while the nocturnal temperature falls still in a greater ratio. Thus while the heat is intolerable in Santiago de Cuba, in June and July, Cristo, a few miles away, at an altitude of only 800 feet, is delightfully cool. This fact should be taken advantage of in locating barracks and hospitals; even an elevation of 100 or 200 feet is decidedly advantageous.

The principle that soldiers in camp should never sleep on the ground applies especially to tropical countries. If cots are not available, the poncho or slicker should be interposed between the ground and the blanket or overcoat used as bedding; but still better, if time permits, a bedstead should be improvised. The mosquito-bar is never to be dispensed with, except by authority, when the complete absence of mosquitoes has been ascertained.

The cold bath in hot countries is certainly an excellent means to combat the heat and prevent the loss of nervous energy. The swim at the beach or the shower-bath at the barracks cannot be too highly recommended, *provided* it is short and no depressing effect is produced.

To observe the state of his bowels and regulate them as required should be one of the important hygienic cares of the soldier in the tropics. The waste products from excessive proteid alimentation, the sluggish digestion and rapidity of bacteria multiplication greatly increase the danger of auto-infection. Many cases of "undetermined" fever are doubtless the result of the reabsorption of toxic products from the intestinal canal. The heat (or rather the solar actinic rays) so affect the nervous system as to often check the peristaltic motion of the bowels, with consequent constipation. This should be overcome by cold shower-baths, massage and vegetable and fruit diet.

TROPICAL DISEASES.

As has been stated before, constant high temperature and humidity are favorable to the production of microbes, and this explains the rapid decomposition and decay of organic matter in the tropics, with the usual attendant odors. These microbes, however, are practically all saprophytes and harmless to man. As to pathogenic germs in the tropics, the conditions under which they breed and are transmitted are now well understood, with the result that the prevalent infectious diseases which they produce are all preventable and can be stamped out by the application of well-known sanitary measures. Such diseases as leprosy, bubonic plague and cholera continue to lurk in some of our colonies after having disappeared from colder climates, simply on account of the ignorance and indifference of the natives and not because of more favorable conditions for the breeding of germs. There are, however, some insects, parasites and organisms only found in warm countries, so that the infections they generate, like yellow fever and amebic dysentery, do not easily spread in temperate latitudes; but these also are preventable.

By far the most common and widespread diseases in the Philippine Islands, among American soldiers, are venereal diseases (see p. 68). They do not differ in kind from those in the United States but are of a decidedly more contagious and virulent type, the ratio of cases in the Islands being nearly twice as high. They have widely spread since the American intervention and many of the interior towns where they were formerly unknown are now infected.

To sum up this chapter: Any soldier, in the tropics, who takes an intelligent interest in the sanitary measures enacted for his benefit and cheerfully complies therewith, who reasonably adapts his diet to the climate, keeps away from the hot sun when off duty, and shuns the saloon and brothel, has as good chances of health and longevity as in temperate climates.

CHAPTER XXXVII.

SERVICE IN COLD CLIMATES.

A temperature of 40° to 45° F. below zero is not uncommon in some of our interior northern States, while a still more intense cold is experienced in parts of Alaska. The coldest day recorded by Nansen in "Farthest North" while drifting, only a few degrees from the pole, was on January 15, when the thermometer ranged from —58° to —61.6° F. In northern latitudes, when the air is dry and perfectly still, the temperature falls to its lowest point, to rise again as soon as the air becomes disturbed by wind currents. Such calm cold, although intense, is much more bearable than a lesser cold with wind blowing. It is the blizzard that constitutes the dangerous feature of the winter of our northwestern States. As explained in another place, the same degree of cold is much more bearable if dry than if damp; thus a temperature of —10° or —15° in Dakota is less trying and depressing than one of zero on the shores of the Great Lakes, causing a smaller loss of animal heat from the body.

That man can maintain himself in excellent health and lead an active life in climates with extreme winter cold has been amply demonstrated. It has also been shown that, with proper food and clothing, it is possible for troops to conduct an active campaign in winter snow and ice, with temperature often below zero. Several of our successful Indian campaigns were thus prosecuted without a single death from congelation or serious accident attributable to the cold. During the Russo-Japanese War, one of the bloodiest battles, lasting several days, was fought in January, with temperature from 8 to 12 below zero, a sharp wind blowing from the north during much of the time; there were many cases of frost-bite but most of them could have been prevented by proper hand and foot covering.

Severe cold causes loss of body temperature by conduction and radiation, and reduces the force and frequency of the pulse. It constricts the cutaneous capillaries and greatly diminishes perspiration, while the urine is correspondingly increased. Should the exposure be prolonged and severe, the contracting superficial arterioles do not permit enough blood to reach the extremities which become blanched and frost-bitten. Frost-bite, in hands and feet, is generally accompanied by a sharp tingling pain, but may also manifest itself, especially when the result of intense dry cold, by a painless ivory-white spot on the cheek, nose or ear. In general refrigera-

tion, after long exposure, the patient experiences difficulty in speaking; his sight grows dim and his faculties fail him; muscular exertion becomes difficult and he staggers like a drunken man; he is overcome by a sense of languor and an irresistible desire to go to sleep, a sleep which leads to coma and death.

To combat cold successfully, the system endeavors to produce more animal heat by an increased demand for food and by stimulating the digestive and assimilative functions, while the combustion of tissues and elimination of wastes are more rapid and complete. The food, in very cold climates, should be abundant and rich in fats (fat meats, bacon or pork, oil and butter). The Esquimaux is said to eat 12 to 15 pounds of fat meat, raw or cooked, daily, when able to procure it, and to be very fond of raw blubber and walrus beef. The increased desire for rich food, in northern latitudes, may be safely indulged provided one performs active work, or takes brisk exercise; but, with a quiet or idle life, this desire should be restrained and regulated, otherwise accidents of auto-infection or disorders of nutrition are sure to result.

Experience has shown that alcoholic drinks, except in great moderation, are especially dangerous in cold countries, and that men are healthier and capable of greater endurance to cold and fatigue without them. This has led to the entire suppression of the daily dose of rum or whiskey which was formerly part of the ration of the crews of whaling vessels and other ships cruising in the northern seas. When Nansen sailed for the north pole, the only spirits on board his ship were a few bottles of cognac in the doctor's stores; he returned after a three years' strenuous cruise with every member of his expedition in the best of health.

The most suitable clothing is woolen undergarments and fur outer-garments. The buffalo fur coat formerly worn by officers and men in winter expeditions is now replaced by a thick canvas overcoat lined with heavy blanket cloth. Buckskin suits are excellent, keeping out the cold wind and saving the body heat without impeding overmuch the aëration of the skin. The extremities require special attention. For the feet there is nothing better than the woolen stockings, felt shoes and Arctic overshoes provided by the Quartermaster's Department. Care must be taken that the feet are not compressed, and that nothing interferes with the free circulation of blood in the toes. For the hands, mittens are better than gloves, and the fur mittens of muskrat skin lined with lamb's fleece, issued to our soldiers in very cold latitudes, can hardily be excelled. Mittens of tan buckskin are also provided when needed. For the head, the fur muskrat cap formerly issued to the men is a most excellent cover-

ing. It is to be replaced by the less expensive canvas cap lined with olive-drab kersey, with visor to protect the face, and extended below into a cape to cover the neck and throat. For bedding, the best device is the sleeping-bag of the Arctic explorer and Canadian voyageur, made of strong canvas lined with fur.

In marching, certain precautions are required. If the face suffers from the cold it should be anointed with cold cream, vaseline or any kind of grease. To guard against the glare of bright sunlight upon the snow, so injurious to the eyes, colored glasses are useful, or else wooden spectacles with a slit cut through them, as worn by the Esquimaux. The column should march in close order so that the men may shelter and protect one another. No straggling must be permitted. There is always great danger that men exhausted by the march, mentally and physically benumbed by the cold, may drop out, if unobserved, yield to their intense desire to go to sleep and freeze to death; then "whoever stops goes to sleep, and whoever goes to sleep wakes no more." Such men must be urged, helped, shaken and kept awake at all hazards until shelter is available and rest possible. When undertaking long marches in very cold weather, a sufficient supply of tea and coffee should always be on hand, along with small portable spirit lamps or oil stoves. Alcoholic stimulants, when deemed necessary, may be used in small doses cautiously repeated.

Here may be mentioned the Japanese "pocket stove" which many Japanese soldiers carried on their persons in Manchuria during the Russo-Japanese War; it is semi-cylindrical in shape, one foot long and four inches in diameter; a slow burning powder is the fuel and a pleasant warmth is thus readily produced.

In frost-bite there is more or less congelation of tissue and arrest of circulation. If the frost-bitten part is heated, as for instance with warm water or a hot cloth, with a view to thaw it out and quickly restore the circulation, the effect is disastrous, consisting in disintegration of tissue almost certainly followed by necrosis and gangrene. Therefore the indication is to restore the circulation very gradually. The best method is to rub the affected part with snow or ice until the normal hue of the skin returns, or if the whole hand or foot is involved, to plunge it in very cold water and apply brisk and persistent frictions. In the case of general congelation, the patient must not be carried at once into a warm place, but kept for a while in a shed or fireless room; there the body is rubbed with dry towels and the extremities treated as in frost-bite; heart stimulants will probably be needful.

CHAPTER XXXVIII.

DISINFECTION AND DISINFECTANTS.

The term *disinfectant*, although popularly used in a more comprehensive sense, should be restricted to any substance which destroys the specific germs and toxins of infectious diseases. It is practically synonymous with *germicide*. *Disinfection*, therefore, consists in the destruction of pathogenic germs. *Sterilization* has a more extended sense and means the destruction of all micro-organisms. *Antiseptics* are substances which, without killing organisms, lower their vitality so as to arrest their power of propagation, thereby restraining or preventing the decomposition of organic matters. *Deodorants* merely oxidize the products of decomposition and thereby correct or destroy offensive odors without any direct effect upon the causal organisms.

The lines separating disinfectants, antiseptics and deodorants are not strictly drawn, most substances in either class sharing also, more or less, the properties of the other classes; thus disinfectants, when used in small doses, lose their power to destroy germs and become simply antiseptics; for instance, formalin which is an efficient germicide in a strength of 5 per cent., is only an antiseptic and deodorant in a strength of 1 per 3,000.

AIR AND LIGHT.

Fresh air and sunlight, especially on account of their availability at all times, have great value as disinfectants or aids to disinfection. Fresh air oxidizes the organic dust of buildings and thus removes much of the pabulum of bacteria; it acts much more efficiently under the influence of the solar rays. Direct sunlight, chiefly through the actinic effect of the ultra-violet rays, has a strong restraining action on the growth of bacteria and kills most of them in time. The germs of tuberculosis, typhoid fever and cholera are particularly sensitive to it. This effect of light is materially increased by heat, and is most marked with clear, warm sunrays. Diffuse light is much less efficient but also very useful. Germs floating in dry air soon become desiccated under the action of solar heat, and, in this state, lose their power of propagation and often their vitality. The germs of cholera are particularly sensitive to a dry atmosphere.

From the above remarks it follows that nature provides us with simple and useful means of disinfection and antisepsis which should not be neglected. These are the thorough ventilation and sunning of dwellings, the airing, shaking and sunning of clothing, bedding, carpets, hangings, etc. In garrisons, the bedding, clothing and much of the equipment of the men should be regularly aired and shaken once a week, even in the absence of sunlight.

The sterilizing influence of sunlight on the bacteria of drinking water is very remarkable. Thus, within a depth of 2 or 3 feet, the germs of typhoid fever and cholera are quickly oxidized. In clear water this destructive effect extends to a depth of 5 or 6 feet. It is advisable, therefore, for this and other reasons, to draw the water from near the surface of streams and ponds.

HEAT.

Heat may be used dry or moist.

Dry Heat.—This is hardly ever used for disinfection. It requires such a high temperature for its action that it is liable to scorch exposed articles, especially woolen materials; it acts very slowly, and has such a low power of penetration as to make it useless for the disinfection of bulky articles like mattrasses and folded blankets.

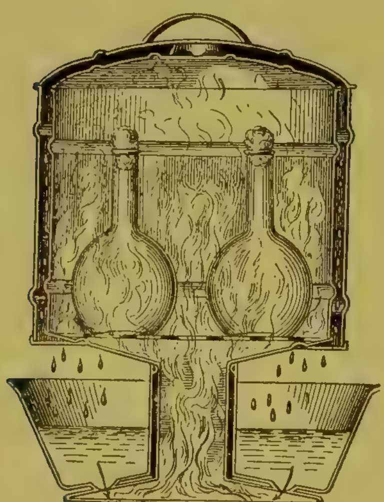

Fig. 217.—Section of Arnold steam sterilizer.

Moist Heat.—This is used in the form of boiling water and steam. *Boiling* is a simple and efficient method of disinfection, especially for cotton and linen goods, as well as cuspidors, bed pans, urinals and a great variety of objects. In half an hour it destroys all bacteria. It is not applicable to woolen goods which shrink and lose their elasticity, nor to leather and rubber goods which become hard and brittle. It has also the objection of fixing and rendering indelible albuminous stains such as those from blood, pus and excreta; fabrics so stained should first be soaked and rubbed in cold water to which a little washing soda is added. For the disinfection of bright steel objects or cutting instruments, the addition of 1 per cent. of soda will prevent rusting and injury to the cutting edge.

Steam.—All things considered, steam is the best and most useful of

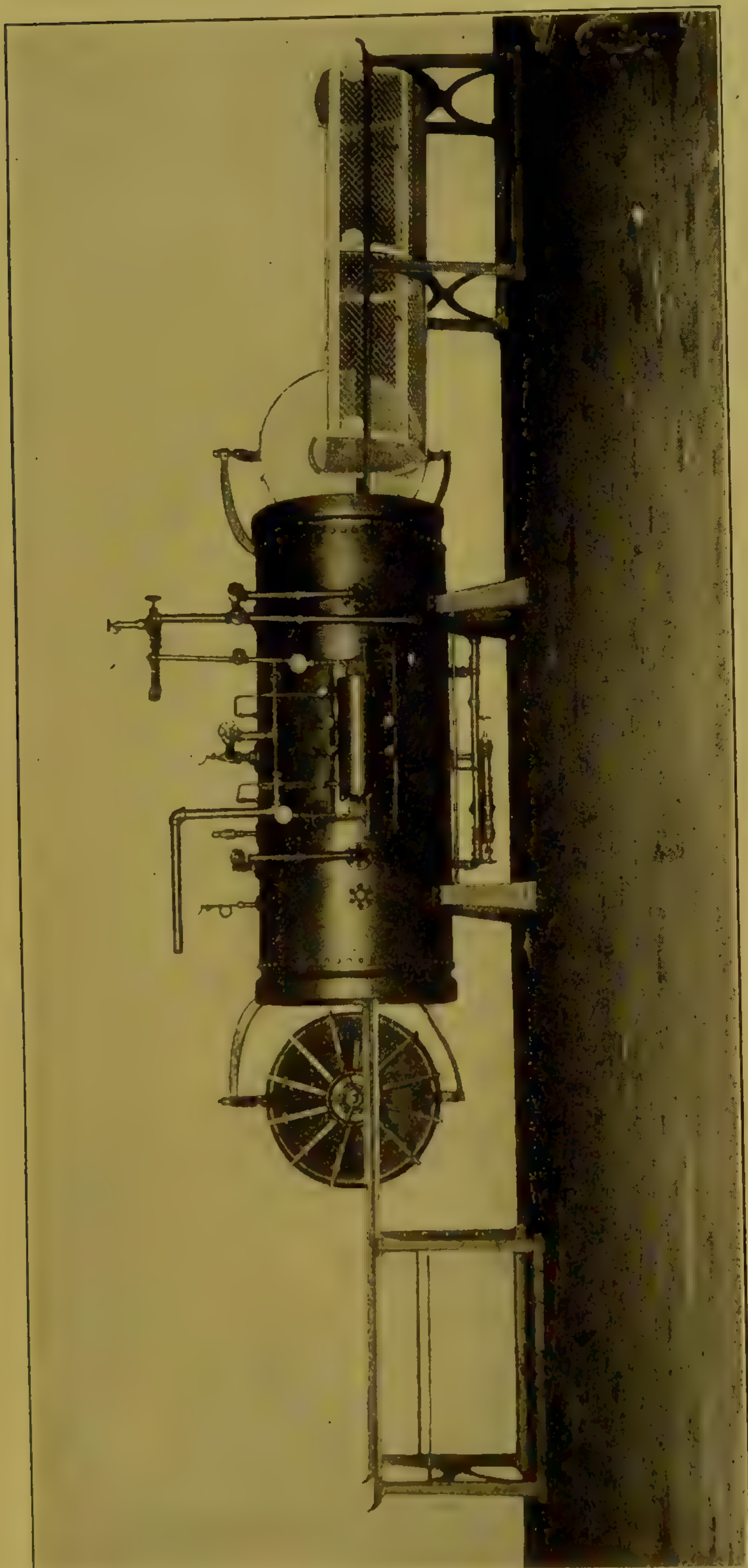

Fig. 218.—Kinyoun-Francis steam and formaldehyde disinfector.

disinfectants, being cheap, reliable, quick, easily manipulated and applicable to a majority of the articles requiring disinfection. It is used saturated or superheated.

Saturated steam is steam as it streams or flows from boiling water under atmospheric pressure only. It is entirely reliable for many practical purposes, killing most bacteria in a few minutes. It has but little power of penetration and therefore can only be used for small, loose articles, or for

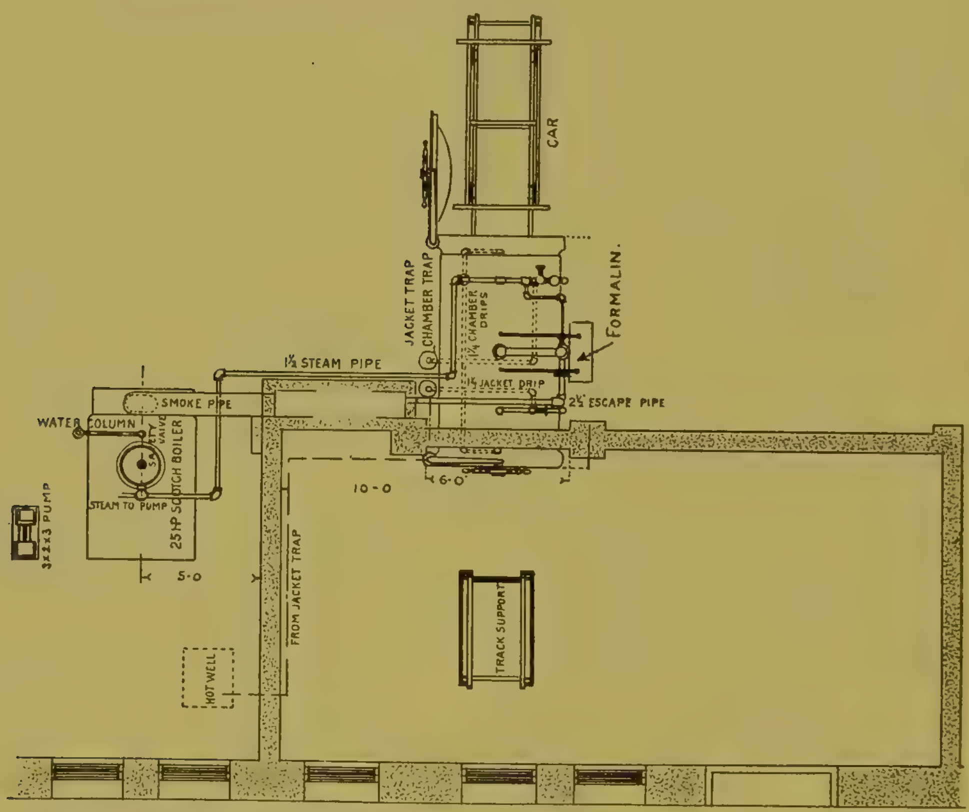

FIG. 219.—Ground plan of disinfecting plant, Fort Slocum, N. Y. (Kensington Engine Works Co.)

the sterilization of dressings in operating rooms. It is successfully utilized in the Arnold sterilizer commonly issued to our post hospitals (Fig. 217); from the pan, the water passes slowly into the shallow boiler from which the steam rises into the sterilizing chamber; the water resulting from condensation drips back into the pan; as the heat is turned off, the hood and lid should be removed in order to let the steam escape and prevent the wetting of the sterilized articles which would result from its condensation.

Disinfection with streaming steam can be readily effected without the use of special apparatus, whenever a boiler is found to furnish the steam; sticks are laid across the top and the material to be disinfected placed over them; the whole should be covered with a sheet to retain the heat, and steamed for at least an hour.

Superheated steam is steam under pressure, and so heated that it can be cooled without condensing, and even take up moisture from surrounding objects. It is the form commonly used for general disinfection. Superheated steam at 230° F. will destroy not only all bacteria but the most resistant spores in a few minutes. It does not injure cotton and linen

FIG. 220.—Pavilion for infectious diseases. U. S. Army hospitals. Front elevation.

articles, nor most household effects, but is quite apt to shrink woolens and damage silk fabrics, while it ruins furs, leather, felt and rubber goods. As in the case of boiling water, spots of blood, pus or feces should be removed prior to disinfection.

Steam sterilizers of various types are found in all large hospitals and public institutions not only for the sterilization of infected articles whenever required, but also for the systematic sterilization of the clothing and effects of all inmates admitted therein, as a measure of prevention. For the use of permanent camps or cantonments, sterilizers mounted on

wheels so as to be drawn to any required place, will often answer an excellent purpose.

The ordinary apparatus (Fig. 218) consists of a chamber of steel large enough to admit mattresses and other bulky packages, with an outer jacket of same metal, and an intervening space of two inches. At each end is a door made to fit air-tight. Inside and outside the chamber are rails upon which rolls a car for convenience of loading and unloading. To operate it,

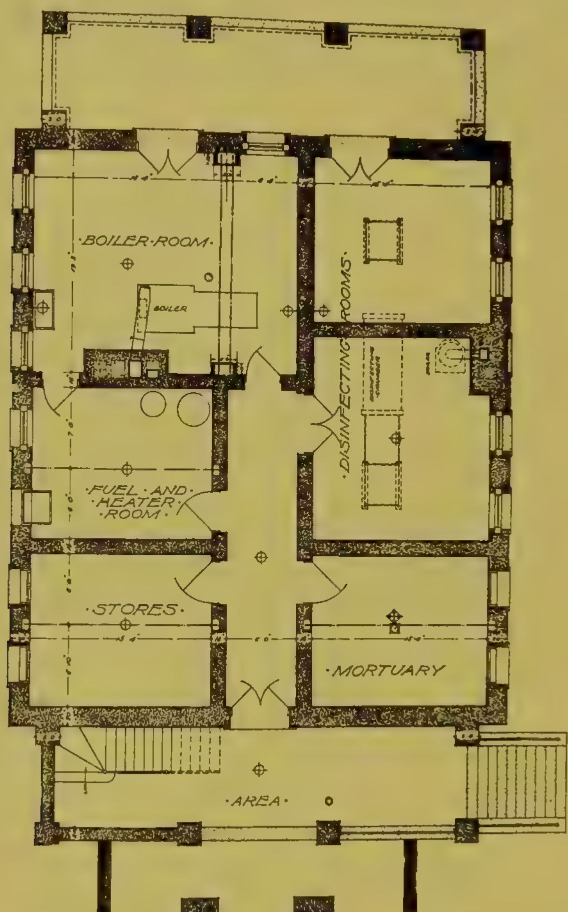

FIG. 221.—Pavilion for infectious diseases. U. S. Army hospitals. Basement plan.

the steam is first let into the jacket so as to warm the chamber and thus prevent the condensation of the steam which would otherwise occur when first introduced. The goods are then placed into the car, rolled into the chamber and the doors closed and made steam-tight. The steam exhauster is now turned on until a vacuum of 15 to 20 inches is obtained; this removes the air and moisture from the chamber and its contents. Air in the chamber would interfere with the penetrating action of the steam and retard the at-

tainment of the required temperature. Steam is then admitted and a temperature of 230 to 240° F. maintained for about 15 minutes, when another partial vacuum is made. A current of air is now drawn through the chamber, the outer door opened and the contents removed. As the result of the combined action of the vacuum and fresh air inlet, the contents are found to be completely dry after 3 or 4 minutes exposure.

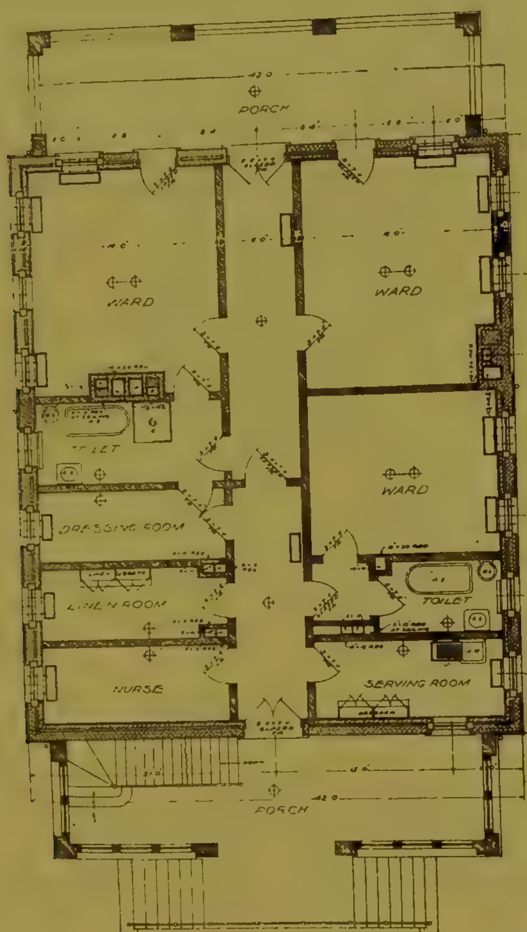

FIG. 222.—Pavilion for infectious diseases. U. S. Army hospitals. First floor plan.

It has been stated above that certain articles are injured by steam. They may be safely disinfected with formaldehyde under pressure, in a partial vacuum; for this purpose, steam chambers are generally provided with a formaldehyde attachment, used as described on page 444.

The body of the apparatus should pass through a partition wall so that the ends of the chamber open into separate rooms, one room being used for the reception of infected articles and the other for their delivery after sterilization. (Fig. 219.)

Our larger military posts have a separate pavilion for infectious diseases (Figs. 220, 221, 222) which is supplied with a complete disinfecting outfit in the basement, generally consisting of the Kinyoun-Francis circular disinfecting chamber with the usual formaldehyde retort attachment.

CHEMICAL DISINFECTANTS.

Chemical disinfectants are conveniently divided into those which are used in aqueous solution and those used under the form of gas.

GASEOUS DISINFECTANTS.

Of the several substances belonging to this class, only few are of practical importance, namely, chlorine, sulphur dioxid, formaldehyde and campho-phenol.

Chlorine.—This gas has powerful disinfecting properties, but on account of its high specific gravity which prevents an even diffusion, its lack of penetrating power, bleaching effects on colors and destructive action on fabrics, it is very seldom used.

Sulphur dioxid, SO_2.—This gas, produced by the burning of sulphur, has long been considered one of our most reliable disinfectants, probably on account of its pungent, irritating and persistent odor, and is still largely employed. The experiments of most bacteriologists, however,

FIG. 223.—Pan for burning sulphur.

have demonstrated that, although it has undoubted germicidal properties under certain favorable conditions, it is untrustworthy for general disinfection. Plenty of moisture is necessary for its action but, even with it, its power of penetration is always feeble, while its high specific gravity renders its even diffusion almost impossible. Furthermore, it bleaches fabrics or materials dyed with vegetable or anilin dyes, injures most metals, and as part of it becomes oxidized, the resulting sulphuric acid corrodes the fiber of linen and cotton goods, seriously weakening their tensile strength. Whenever used as a disinfectant, 4 pounds of

sulphur should be burned to each 1,000 cubic feet of space to produce any marked effect. The sulphur, broken into small fragments, is placed in an iron pot which is itself set on bricks in a tub of water, to guard against the danger of fire, and is ignited after being freely wetted with alcohol (Fig. 223). The room should previously be sealed tight in order to prevent leakage of the gas.

It is as a fumigant that sulphur dioxid finds its most useful application. Sulphur fumes are most effective in the destruction of rats, mice, roaches, bedbugs, flies and mosquitoes, and, for this purpose, acts best in dry air, without added moisture. As an insecticide, 2 pounds of sulphur to each 1,000 cubic feet of space are enough.

FORMALDEHYDE, CH_2O.—A colorless, pungent gas, extremely irritating to the mucous membrane of the nose and eyes, and of the same specific gravity as air in which it diffuses evenly. It is a product of oxidation of wood alcohol and is soluble in water up to 40 per cent., forming the solution known in trade as formalin. If the latter be concentrated by heat, the gas is changed into a white crystalline solid by polymerization, called paraformaldehyde or simply paraform ($C_3H_6O_3$), consisting of 3 molecules of formaldehyde. The gas is changed in the same manner when generated in a cold room or at a low temperature. The readiness with which it is thus polymerized into an inert substance is one of the drawbacks to its use.

Formaldehyde is the strongest and most practically efficient gaseous disinfectant known. It is applicable to the disinfection of rooms, clothing, fabrics, effects and furniture, but cannot be depended upon for mattresses, upholstered furniture, and the like, which require deep penetration; for this purpose, steam is to be used. It has no injurious action on metallic substances, woolen goods, furs, rubber and leather articles, colors and paintings. It is also an excellent deodorant, as it readily combines with and destroys the foul-smelling products of decomposition. It fails to kill vermin and is of but little value even against mosquitoes, unless used in large amounts in tightly closed rooms.

Methods of Generation and Use.—In all these methods (the third excepted), formaldehyde is generated from formalin and may be relied upon as a powerful surface disinfectant under certain conditions, namely, a sufficiently high temperature and degree of humidity. Below 60° F., formaldehyde polymerizes into paraform and has but little value. In the absence of moisture it is practically inert as a germicide; for satisfactory results the relative humidity of the air of the room, before generating the gas, must be at least 60 per cent. In all these methods, about the same

amount of watery vapor is given off, but, for disinfection purposes, this does not seem to answer as well as the natural humidity of the atmosphere (McClintic). Leakage must be prevented by closing all doors, windows, chimneys, ventilators and registers, as well as chinks and fissures, using paper strips and paste very freely for the purpose; sometimes large paulins or ample sheets of strong paper are necessary. Upon the completion of the process, the best way to get rid of the gas is to open all the doors and windows and let it blow away. Ammonia may be sprinkled about the room to neutralize it, but the resulting substance (formamid) has such a persistent odor that this is now seldom done.

Of the many methods of generating formaldehyde, the most practical and efficient are:

1. *With Retort, Without Pressure.*—Of this the Trenner Lee generator is a good type. It consists of a copper retort from which formalin can be readily and conveniently vaporized, either from outside or inside the room, without pressure and automatically.

2. *With Autoclave, Under Pressure.*—This requires a somewhat complicated apparatus, not free from danger, and only used from the outside. The gas is very quickly liberated under a pressure of about 3 atmospheres. To the formalin should be added 20 per cent. of calcium chloride or some other neutral salt to prevent polymerization and facilitate the evolution of the gas. (Fig. 224).

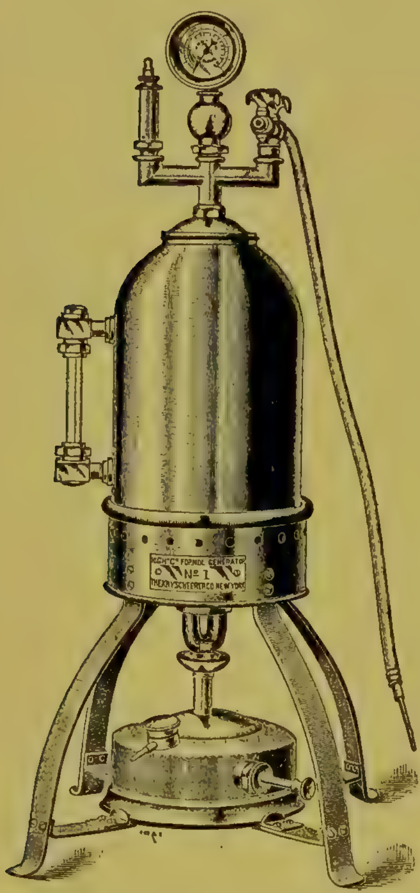

FIG. 224.—Autoclave formaldehyde generator.

3. *With Generating Lamp.*—Of this the Kuhn generator is the best type. The gas is obtained by the oxidation of methyl or wood alcohol brought about by the action of incandescent platinized asbestos, and is therefore in its nascent or most active state. The pan containing the alcohol is surrounded by water which is slowly vaporized. Three pints of alcohol are required to disinfect 2,000 cubic feet of space. One of the disadvan-

tages of this lamp is that the gas is generated very slowly so that it lacks the penetrating power of the quicker processes; but, on the other hand, it does not show the same tendency to polymerize into paraform (Figs. 225 and 226).

4. *Formalin-Permanganate Method.*—This is based upon the fact that when formalin is poured upon potassium permanganate, a violent reaction takes place with strong ebullition of the mixture, rapid generation of formaldehyde and considerable vaporization of water. The reaction is over in 5 minutes and leaves hardly any residue. The average yield of gas is 81 per cent. of the amount present in the solution. The best proportion of formalin and permanganate is two to one, namely 200 cubic

FIG. 225.—Kuhn formaldehyde generator. Filling. (*Rosenau.*)

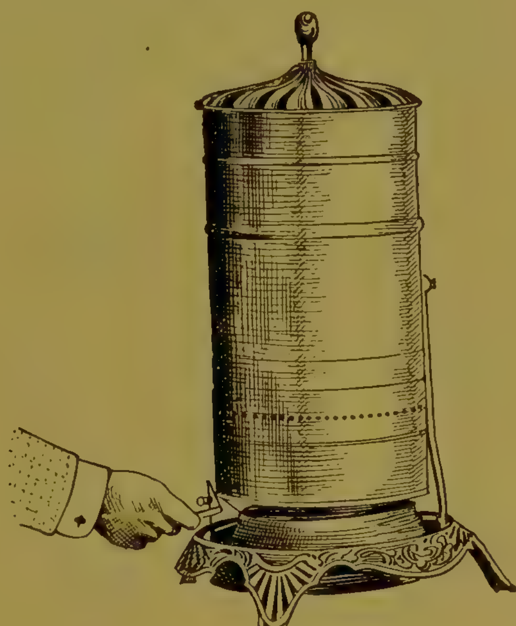

FIG. 226.—Kuhn formaldehyde generator. Lighting. (*Rosenau.*)

centimeters of the former to 100 grams of the latter, which is the amount required for each 1,000 cubic feet of space. On account of the frothing and sputtering which occur, the permanganate should be put in a tin vessel, 10 inches wide at bottom and about 18 inches high, preferably with sides flaring out toward the top. This vessel is placed in a shallow tub of water, or simply upon a piece of stout brown paper projecting a couple of feet all around it to catch the sputtering drops and protect the floor. Formaldehyde being inflammable care must be taken that there is no gas jet or flame of any kind in the room. To obtain the best bactericidal results the charge of permanganate in any one vessel should not exceed 200 grams.

For simplicity and rapidity this method is superior to any other. It liberates the gas almost instantaneously and in nearly as large quantities as the retort and autoclave methods which it has largely superseded. No advantage is gained by adding water to the formalin before mixing with the permanganate. For the best result the temperature of the room should not be less than 65° F.

5. *Sheet-spraying Method.*—For each 1,000 cubic feet of space, a sheet 5 by 7 feet is hung up in the room to be disinfected, in a slanting position, at an angle of about 45°. It should be wrung out of water so as to be just damp to the touch when hung up. Three hundred cc. (about 10 ounces) of formalin are then uniformly sprayed upon it, so that the small, discrete droplets will not run together. The room must be tightly sealed and kept closed at least 24 hours. This method is not applicable to rooms or apartments of a much greater capacity than 2,000 cubic feet, as the very slow evaporation from the sheets would not be equal to the loss from leakage. It is fairly efficient when long exposure is not objectionable and the weather is warm (at least 75° F.) or the house artificially heated. In cold weather very little gas is liberated and it quickly polymerizes.

6. *With Steam Chamber and Dry Heat in Partial Vacuum.*—This method requires a special apparatus, such as the Kinyoun-Francis disinfecting chamber with formaldehyde attachment, in which may be obtained a high percentage of formaldehyde, a temperature of 175° F. and a vacuum of 15 inches. The attachment consists of a copper retort (Fig. 218) in which the formalin, mixed with calcium chloride, is heated by means of a copper steam coil. It is very reliable, quick, not destructive, and gives good penetration although lacking the deep penetrating power of steam. It is applicable to baggage, clothing, household effects, and especially to articles liable to be damaged by steam. Letter mail is rendered safe by this process without puncturing the envelopes.

To operate the apparatus, the steam is first turned into the jacket and the chamber heated to 175° F.; the steam ejector is then set to work until a vacuum of 15 inches is produced; the formaldehyde is now forced in from its retort under a pressure of 3 atmospheres. At least three ounces of formalin (to which 20 per cent. of calcium chloride is added) should be used for every 100 cubic feet. An exposure of one hour to these combined conditions is ample for thorough disinfection. At the completion of the process the formaldehyde may be neutralized by ammonia from a special retort; but, according to Rosenau, it is simpler and better to open both doors of the chamber and allow the gas to blow away.

Simple Spraying.—Spraying formalin upon walls, floors and furniture is always an excellent additional precaution just before or after the application of any of the methods of room disinfection. Formalin can also be successfully used to disinfect contents of trunks and boxes, but, for this purpose, it will not do to simply pour it into the corners; it should be carefully sprayed or sprinkled in small drops and distributed uniformly between many layers, using from 2 to 3 ounces per cubic foot (Rosenau).

Formalin-phenol Method.—What may be designated by this name is the method lately described by W. B. McLaughlin who proved that if formaldehyde is mixed with vapor of carbolic acid its tendency to polymerization ceases, while its power of penetration is much increased. He uses a mixture of 75 parts of formalin and 25 parts of carbolic acid, 8 ounces of which, to each 1,000 cubic feet of space, are volatilized from a retort or sprayed on sheets. By this method, resistant strains of bacteria were killed through 12 layers of blankets, under conditions where formaldehyde alone would not penetrate 3 layers.

CAMPHO-PHENOL (CAMPHO-PHENIQUE OR MIMM'S MIXTURE.)

This preparation, although a rather feeble disinfectant, may be mentioned here on account of its marked efficiency as an insecticide, having been successfully used for the destruction of mosquitoes. It consists of a mixture of equal weights of camphor and carbolic acid. Two ounces of camphor dissolved in two ounces of carbolic acid (95 per cent.) are required to each thousand feet of space. The vapor, as generated by the heat of an alcohol lamp, has a pungent odor but is not nearly as objectionable as that of sulphurous acid. This mixture has great advantages over pyrethrum and sulphur as a culicide, being cheaper than the former, quicker in its action and much more efficient. Its disadvantage is that it is quite inflammable, burning with an intensely smoky flame covering everything with a layer of soot difficult to remove. To prevent this, care must be exercised or a special lamp used.*

DISINFECTING AGENTS IN AQUEOUS SOLUTION.

Bichloride of mercury or mercuric chloride, popularly known as corrosive sublimate, is the most powerful of all metallic salts as a disinfectant under favorable conditions. A solution of 1/1000 is generally stated to destroy ordinary bacilli, free from spores, in a few seconds. Experimenters differ rather widely in their views of its efficiency, but it is evident

*Bulletin No. 2, Board of Health, Isthmian Canal Commission. 1906.

that the high reputation given it by former observers must be modified. It has three great disadvantages: it is virulently poisonous, corrodes metals, and forms with albumin an inert insoluble compound. Its solution, when in contact with certain mineral or organic substances, is also liable to precipitate as calomel, sulphide or other insoluble compound. In the treatment of excretions, for instance, such as sputum or feces, a coagulum of albuminate is formed on the surface which protects the innermost bacilli from contact with the disinfectant. This may be prevented by the addition of 5 parts of acid (sulphuric, hydrochloric or tartaric) or 10 parts of common salt for each part of sublimate. According to Harrington, a solution of 1/10000 will promptly sterilize certain bacteria when their resistance has been lowered by desiccation, while a solution of 1/5000 is ineffective against the common pathogenic bacteria in a moist condition. According to the same authority, even 1/1000 solution requires at least 10 minutes to kill some of the commonest of the skin bacteria, so that it would be of advantage to abandon its use in surgery.

The tablets and solutions of this salt are generally colored with aniline blue or some other neutral dye to identify them and prevent accidents.

Mineral acids possess decided disinfecting powers and may be used, largely diluted, wherever their corrosive action is not objectionable. A solution of 0.02 per cent. of hydrochloric acid kills the cholera organism in 2 hours, and one of 0.07 per cent. the bacillus of typhoid fever in the same time, while a solution of 0.08 per cent. of sulphuric acid will sterilize foul sewage in 15 minutes.

Formalin, a 40 per cent. solution of formaldehyde already described, is extensively used, in variable degrees of dilution, as a most valuable disinfectant, antiseptic and deodorant. Thus a solution of 1 to 3,000 or 4,000 restrains the growth of all pathogenic bacteria, while a 10 per cent. solution mixed with fecal discharges renders them odorless at once, and completely sterile within an hour. Tubercle bacilli in sputum are killed by a 5 per cent. solution in 60 minutes.

Carbolic Acid (*Phenol or Phenic Acid*).—A product of the distillation of coal-tar. When chemically pure (phenol) it forms white crystals which dissolve in 11 parts of water. The "liquefied phenol" of the pharmacopœia dissolves in 12 parts, while the so-called pure acid of commerce, which contains more or less cresols, dissolves in 20 parts. The crude acid, which is the form generally used for disinfection, contains variable amounts of cresols and other similar strongly bactericidal bodies, as well as inert tar oils. A solution of 3 to 5 per cent. destroys all the

ordinary pathogenic bacteria in sputum and excreta in a few hours. As it does not injure fabrics nor affect wood, leather or metal, its range of application is very great. Carbolic acid dissolved in alcohol is stronger than in aqueous solution, but loses its germicidal properties when dissolved in oil.

The *cresols* occur as impurities of carbolic acid and are generally combined under the trade name of "tricresol." They are about twice as powerful as carbolic acid and, in a 1 per cent. solution, promptly destroy the pus-producing organisms. They are extensively used under many preparations; being insoluble in water they are combined with various solvents or made into emulsions. Of the best-known preparations may be mentioned *lysol* and *creolin*. Lysol contains about 50 per cent. of cresols dissolved in potash soap; it is fully as strong as carbolic acid, miscible in water in all proportions, and extensively used in surgical practice. Creolin is a dark brown alkaline liquid containing about 10 per cent. of cresols.

Chloride of lime or more properly *chlorinated lime*, is a white powder of somewhat unstable nature, obtained by the exposure of water-slaked lime to nascent chlorine gas. To be efficient it must contain at least 25 per cent. by weight of chlorine. As it readily undergoes decomposition, it should be kept in tight vessels in a cool and dry place. Its composition, although still uncertain, is generally considered to be a mixture of calcium chloride and calcium hypochlorite. It is an effective disinfectant in a solution of 5 per cent. or even less. A solution is best made by triturating the requisite amount in water to the consistency of cream and then diluting to the required volume. Chlorinated lime is commonly used as a deodorant on account of its great affinity for hydrogen, readily decomposing hydrogen sulphide, ammonia and other volatile odorous substances. It must be remembered, however, that its own odor is often quite objectionable.

Quicklime or *calcium oxid*, is an excellent disinfectant well adapted to military needs. Treated with about one-half its weight of water, it evolves considerable heat and becomes hydrated or "slaked." "Milk of lime" is made by thoroughly mixing slaked lime with from 4 to 8 parts of water. If more water is added, the familiar "white wash" is obtained. Lime dissolves in 700 parts of water, yielding a clear solution which is "lime water." When exposed to the air, quicklime is rapidly acted upon by carbon dioxid, and most of it becomes changed into carbonate which is practically inert; hence the necessity of always using freshly burned and slaked lime.

Lime has been proved to be a strong and reliable disinfectant, especially

in the treatment of fecal discharges; it can be used as dry powder, but fresh milk of lime, of 15 to 20 per cent. strength, is preferable. At least as much should be added as the bulk of matter to be disinfected, and thoroughly mixed with it; in this way complete sterilization may be expected in an hour or two. It is probable that lime of good quality is very nearly, if not quite, as good a disinfectant as the average chloride of lime, while it is much cheaper and odorless. Whitewashing the walls of barracks, cellars, store-rooms and outbuildings is an excellent practice; for this purpose chloride of lime can often be advantageously mixed with the lime. The sprinkling of dry powdered lime on infected soil, or soil liable to be infected, as, for example, around the edges of latrines, along picket lines, or in the vicinity of kitchens, laundries and lavatories, is always advisable and often necessary.

Ferrous sulphate, also called sulphate of iron or copperas, occurring in green, efflorescent crystals, has been extensively used as a deodorant, especially for the removal of odors from privies and vaults. It is useless as a disinfectant and has very little claim to be considered even a deodorant.

ROOM DISINFECTION.

So long as a room is occupied by the patient, disinfection is impossible, but every effort should be made to prevent the dissemination of infectious material; to that end the rules to be observed are thus comprehensively formulated by Harrington.*

"In order to prevent or restrict the carriage of living organisms from the room, ingress should be denied to all whose presence is unnecessary; the wearing of other than cotton and linen dresses, that is, smooth-surfaced and washable, by the attendants should be interdicted; no food remainder should be taken away to be consumed by others; no used bed-linen or body-linen removed until after immersion in disinfectant solutions, and no discharges finally disposed of until after appropriate treatment. If it be necessary to use the broom, the dust should be kept down by the use of wet sawdust or tea leaves, which, with the gathered dirt and dust, should be treated with disinfectant and burned."

In any case of infectious sickness, all linen used in the room and liable to have been infected must be thrown into a tub, immersed for an hour in a disinfecting solution and then carried under cover or wrapped in a disinfected sheet to the laundry. The solution may be of corrosive sublimate (1/1000), carbolic acid (5/100), cresol (3/100), or formalin (4/100). Chlorinated lime is liable to injure fabrics and therefore not suitable for

* Manual of Practical Hygiene, Charles Harrington. 1905.

this purpose. All eating utensils should be well scalded after meal, each patient having his own set, not to be used by anybody else.

For the disinfection of rooms, formaldehyde gas combines more of the requirements of the ideal disinfectant than any other so far tried, and is now almost exclusively used for the purpose. But all hygienists recognize that the complete destruction of bacteria in an infected room, by the application of any gas, is extremely difficult, generally impossible, and that the result, although undoubtedly useful, is nearly always imperfect. It is necessary therefore to have recourse to supplementary measures before and after the application of the gas. In the first place, if a steam sterilizer be available, mattresses, pillows and stuffed articles should be removed (wrapped in disinfected sheets) and treated in it. If the stuffing be of inexpensive material it is best to burn it, while the ticking can be disinfected and boiled. The contents of the room should be so arranged as to be easily reached by the gas on all sides: articles of furniture moved away from the walls, clothing and bedding suspended on lines, pockets turned inside out, and drawers of all bureaus and cabinets left open. The careful closing of all openings and sealing of all cracks and fissures has already been dwelt upon.

After the fumigation, the carpets and hangings should be exposed to the sunlight and beaten; the floors must be scrubbed with a solution of chloride of lime (1/100) or of corrosive sublimate (1/2000), and the walls sprayed with the same or, still better, a solution of formalin (5/100). Should the walls be covered with soiled and cracked paper, it is best to remove it so that they may be rekalsomined and new paper put on. All woodwork and articles of furniture not liable to be injured thereby should be washed with soft soap and hot water, followed, if deemed necessary, by formalin spray.

For disinfection of ships, see *Marine Hygiene*.

Disinfection of the hands is frequently necessary in the nursing of infectious diseases. Bearing in mind that soap has decided germicidal properties, the process should always begin with soap and warm water, followed by immersion in a 3 per cent. solution of formalin, carbolic acid, cresol or lysol.

Disinfection of Feces.—The fecal discharges in typhoid fever, dysentery and cholera, as often stated, contain most of the excreted infectious germs and therefore must be carefully treated. The amount of disinfectant should be *at least* equal to that of the discharges, thoroughly mixed with them and allowed to stand for about an hour before final disposal. Formalin (5/100) is best for the purpose. Milk of lime is too bulky for water-

closets but very useful in camps. Chloride of lime, carbolic acid and the cresols are also effective and may be used whenever the odor is not found objectionable. In typhoid fever, the urine should be disinfected with about a twentieth of its volume of formalin.

Disinfection of Sputum.—In tuberculosis and pneumonia, special individual spit-cups should be used, partly filled with disinfectant and kept covered. A 5 per cent. solution of carbolic acid, or 4 per cent. of cresol or formalin, is best for the purpose. Paper spit-cups, which are afterward thrown into the fire, are still better. The discharges from the mouth and nose in diphtheria, tonsillitis, whooping-cough and cerebrospinal meningitis should be received in rags and burned.

CHAPTER XXXIX.

NAVAL AND MARINE HYGIENE.

The application of the principles of hygiene to ships is, in many respects, very different from their application to troops on land and requires special consideration. The whole subject is now undergoing careful study and revision by the Medical Department of the Navy. In this Manual it is only intended to advert to its most important features.

A war ship is comparable to a small active manufacturing town, with a crowded population of carpenters, blacksmiths, electricians, firemen, coal-heavers, machinists, gunners, etc. surrounded by complex mechanical devices and exposed to many dangers which menace life and limb.

A ship at sea is entirely thrown upon its own resources and must make the most of the special and inevitable conditions in which it is placed. These conditions are favorable and unfavorable. Sea air is free from micro-organisms and all obnoxious organic matter; it is healthy, invigorating and not liable to sudden or great changes of temperature; advantages from which the seaman benefits. The vital question of the disposal of excreta and wastes presents no difficulty since everything is thrown into the sea. The water, usually distilled, is therefore of unquestioned purity, while the quantity and quality of the food are also more under control and easily maintained to the proper standard than among troops on land. The men, while afloat, are constantly under military discipline and precluded from indulging in dangerous dissipation. Finally, it is easier on a ship to direct and supervise the application of all sanitary measures, as well as to detect and isolate the first cases of infectious diseases than in a camp or garrison.

The great and irremediable drawback of life aboard is restricted space, causing inevitable crowding, close intercourse and personal contact, together with more or less community of effects and clothing, all conditions most favorable to the transmission of communicable diseases. Ventilation of various degrees of excellence can be secured above, but is often very unsatisfactory below decks, especially in the depths where engineers, mechanics, firemen and stokers perform their habitual duties. Physical exercise, so necessary to all young men (especially walking and running,

that easiest and best form of exercise), is quite restricted, often impossible, or else becomes an irksome task.

It is somewhat difficult to balance these advantages and disadvantages of life afloat and draw conclusions as to its effect upon human health. According to the mortuary records in the reports of the Surgeon-General of the Navy for the years 1906 and 1907, only 73 men died of disease on board vessels out of a total disease mortality of 318. Of the four diseases which caused the highest mortality in the Navy, viz., tuberculosis, pneumonia, typhoid fever, cerebrospinal meningitis, there were 11 deaths afloat and 91 ashore. From these and other data it has been pretty conclusively shown that, while cruising, seamen have better chances of health (accidents disregarded) than while on shore duty, or than soldiers in garrison.

A comparison between the statistics of the Army and Navy for the year 1907 (an average normal year) is interesting. The ratio of deaths in the Army was 5.81 per thousand of strength, namely, 3.44 from disease and 2.37 from other causes; for the Navy, 5.67, namely, 3.49 from disease and 2.18 from other causes. The five diseases with the highest ratio of deaths are the same in both services, in the following order of mortality: For the Army, tuberculosis, pneumonia, cerebrospinal meningitis, typhoid fever and heart diseases; for the Navy, pneumonia, typhoid fever, cerebrospinal meningitis, tuberculosis and heart diseases. While the rate of discharges in the Army was 20.15 per thousand, it was 28.57 in the Navy, a notable difference, probably exerting a marked influence in lessening the mortality of the Navy. The most remarkable discrepancy, however, between the two services is in the ratio of admissions and readmissions (to hospital or treatment involving exemption from duty), being 1218 per thousand in the Army and only 740 in the Navy, with a ratio of constantly non-effective of 46 in the Army and only 31 in the Navy. Evidently this discrepancy is to be explained chiefly by the different methods of accounting for the sick and wounded in the two services, especially in recording minor ailments; but, after making this allowance, it seems quite probable that the morbidity in the Navy is somewhat less than in the Army, and that this better showing is mainly due to the excellent health prevailing among the men afloat.

In the British Navy, the death rate for 1905, was only 3.9, namely 2.74 for disease and 1.15 for injuries, with admission rate of 735 and discharge rate of 23,89.

Comparing the prevalent diseases in the Army and Navy, for 1906 and 1907, they are found to be closely analogous. The most notable difference

is in the case of rheumatic affections which, as would be expected, have a somewhat higher ratio in the Navy; more common also on ships are some of those infectious diseases specially favored by crowding, such as influenza, measles and mumps. The confinement of many men, particularly among the engine and fire-room forces, below decks, where they are deprived of sunshine and a free circulation of air, and the violent changes of temperature to which they are subjected, cause a higher rate of admission for tuberculosis in the Navy; but, apparently on account of the greater number of discharges for disability, the ratio of deaths for that disease is somewhat smaller than in the Army.

One class of ear injuries much more frequent in the Navy than in the Army is that caused by the firing of heavy guns. To prevent this the usual practice, until lately, was for each man to place a pledget of cotton in each ear, loosely packed, and keep his mouth slightly opened so as to maintain full air pressure in the Eustachian tube. Recently a special device, called the Elliot ear protector, has been adopted in the Army and Navy and found very satisfactory. It consists essentially of a perforated celluloid ball, of the proper size to fit the auditory canal, with wing to hold it in position. Another preparation, a mixture of molder's clay and wool, has been adopted by the British Admirality as a means of ear protection, and is also being tried on some of our ships.

RECRUITING.—Recruiting in the Navy is governed by practically the same regulations as in the Army. To enlist, applicants, as a general rule, must be 21 and not over 35 years old, but these limits admit of exceptions; thus an ordinary seaman may enlist when 18 and not over 30 years old; an apprentice seaman when 17 and not over 25. May also enlist at 18, landsmen (not for seaman branch), hospital apprentices, mess attendants and ship's cooks.

The standard of vision is higher than in the Army, although the necessity for this is not apparent. A minimum visual acuteness of 20/30 is required in each eye for all applicants, but no man can be a gun pointer who has not a vision of 20/15 in the right, or aiming eye, (that is to say, who cannot read at 20 feet the line on the test card normally read at 15 feet) and a vision of 20/20 in the other eye. The reason given for this high requirement in gun pointers is in order to eliminate certain ocular defects, such as minor degrees of astigmatism.

Owing to the great strain to which the sense of hearing is subjected by the firing of guns aboard, great care is taken in the examination of the ears to ascertain that the drums are sound and the Eustachian tubes patent.

VENTILATION.

On board ship the air space is a variable quantity and difficult to determine, depending upon the size of available compartments, the amount of stores, furniture and baggage they may contain, and the number of men to be berthed in each. This space is necessarily restricted, sometimes to an almost inconceivable degree, but it should never fall below 140 cubic feet, which is hardly any more than the area of the hammock multiplied by the height of the deck. English law requires that in forecastles each bunk should have at least 72 cubic feet entirely free from stores; but according to the best authorities this minimum should never be less than 100 feet. The sick bay on our modern ships is given all the space that is deemed practicable; thus, on the U. S. S. Maryland, it is 10 feet high, contains 35 folding metal beds in pairs, and each bed has an air space of 260 feet. The effect of such close confinement is, of course, mitigated by the free aëration, natural and artificial, of the compartments, and by the fact that watches are changed every four hours so that, except on troop-ships, few men sleep continuously the entire night in foul air.

The construction and equipment of troop-ships (transports) is of the highest importance for this country and has already received careful attention from the War Department, on account of the frequent changes of the regiments stationed in our distant colonies. They should never have more than two decks, preferably only one, occupied by the berths of soldiers. Twenty square feet of floor space should be allowed as a minimum, and not more than two tiers of hammocks or bunks permitted. "Where bunks are used, the lower tier should be raised not less than 18 inches above the deck; with not less than 3 feet between the two tiers, and between the upper tier and the ceiling, so as to enable the occupants to sit upright. All bunks should be arranged so as to leave a passage-way at least 30 inches wide between each other and the side of the ship, to facilitate cleansing, allow ready communication and ventilation" (Munson). In dimensions, the bunks should be no less than 6 feet 3 inches by 2 feet. A high standard of cleanliness on board troop-ships is of the utmost importance. As a large proportion of the men will be the victims of seasickness for a few days, special arrangements must be made to catch vomited matters, for their prompt removal and the cleansing of soiled floors and furniture.

The ventilation of a ship is always a complicated problem, seldom successfully solved for various obvious reasons: The immersion of the larger part of its body which precludes openings, while many of those above

the water-line have often to be kept closed; the special causes of pollution to which its atmosphere is exposed; its structural irregularity, involving many compartments of different shapes and sizes and used for a variety of purposes.

The air of a ship is contaminated by the breathing of its inmates, the combustion of fuel and illuminants and by soiled clothing and bedding, as are barracks, but to a much higher degree on account of the greater crowding. There are, however, other contributory causes of pollution more or less special to ships: the profuse perspiration of the men in the boiler- and engine-rooms, and other heated compartments; the charred organic dust of the air; the gases from coal bunkers, products of heat and moisture; the effluvia from heated oil and grease, from tar, paint, bilge water, vomited matters, water-closets, galleys, mess-rooms and from the components of the store-rooms and cargo.

The bilge water is the drainage of the ship, to which, in wooden ships, is added more or less leakage from without; the putrefaction of the organic matters it contains, together with the sulphides derived from the sulphates of the sea-water, give it a most repulsive fetid odor. In modern iron ships it collects into the *main drain* which runs nearly the whole length of the ship, and seldom accumulates to any objectionable extent, the drain being frequently pumped out and flushed.

Next to the bilge, the fore- and after- peaks are the most insanitary parts of vessels and likewise require special attention.

The bedding should be thoroughly aired once a week when the weather permits, the blankets and mattress covers washed twice a year and the hammocks once a month.

The ventilation of ships, like that of buildings, is natural and artificial. Natural ventilation is effected through hatchways, skylights, stairways, hollow masts, port-holes, side-lights and other openings, as well as through revolving tubes with hood or cowl made to face the wind, and windsails or canvas cylinders used in the same manner. The principal outlets for foul air are the casings or jackets of the funnels, in which the heat causes a strong up-draft. In living spaces the air-ports are usually provided with pivoted side-lights by means of which the air can be scooped in or directed outward as desired. Inlets may become outlets with change of wind or temperature.

On troop-ships effective ventilation demands that every possible obstruction to the circulation and diffusion of air be removed; hence large chests and bulky articles should not be allowed in quarters. Bulkheads must be as few as possible and always partly opened or latticed. An

ideal berth-deck on such ships would be one consisting of a single open compartment running the whole length of the vessel. Passage-ways, longitudinal and transverse, should be as straight as possible so as to favor the free movement of air.

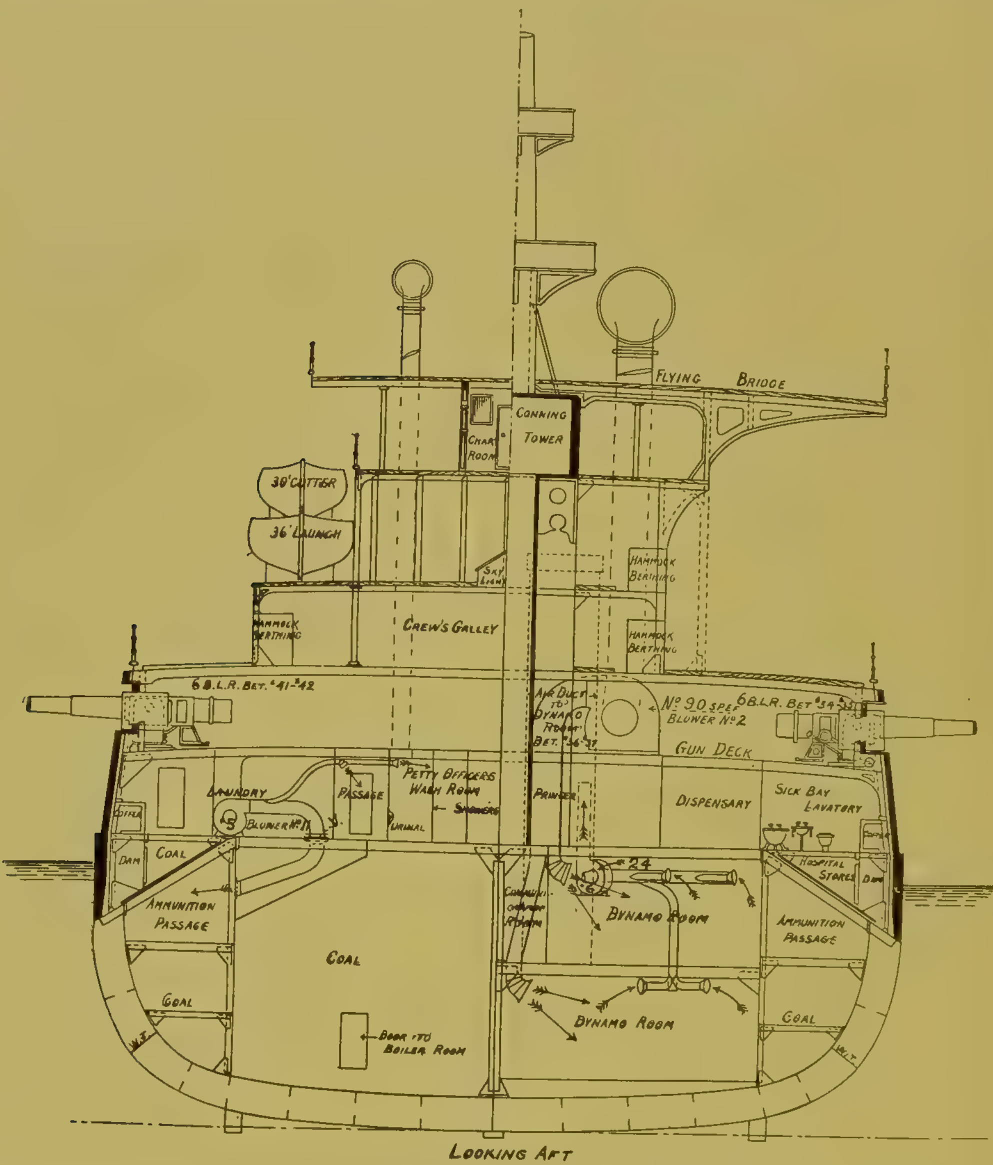

FIG. 227.—Cross section of ship showing system of ventilation in our Navy, by propulsion and extraction.

Natural ventilation, however, although very valuable, is irregular, unreliable and, except for the upper decks, often insufficient.

In engine-rooms the air should be changed at least every two minutes; in dynamo-rooms, every minute; in all quarters and living space, every

12 minutes; in water-closets, wash-rooms, storerooms, magazines, every 8 minutes. The amount of air needed in engine- and boiler-rooms varies also with the speed of the ship and the draft of the fires. Only artificial or mechanical ventilation can always meet such requirements. Two systems are used; namely, propulsion, whereby the fresh air is driven in by electric fans or blowers, and extraction or exhaustion in which the foul air is drawn out. Until recently the exhaust system had been depended upon in battleships to a much greater extent than is approved by good hygiene; although generally satisfactory on the upper decks, it is quite inadequate below the armored deck, especially within the citadel, for want of enough chance inlets to admit fresh air. It also frequently draws air from contiguous compartments, and may thus cause fouling of living quarters. It is indicated for water-closets, lavatories, pantries, storerooms for volatile supplies, galleys, laundries and isolation rooms.

As a general rule, however, experience has shown that both systems are necessary for complete ventilation, and therefore a double set of ducts or trunks, one for supply and the other for exhaust. Each important compartment should have its own ventilating system for the movement of air is much impeded by bends in the distributing ducts. The inlets and outlets should be as far apart as possible so that the fresh air may diffuse itself and fulfill its purpose before escaping. Thus in boiler- and engine-rooms the best method would seem to be to propel the air in through or near the floor by many jets, and aspirate it through the ceiling by a number of outlets leading into an exhaust trunk opening above the upper deck.

Air ducts, on account of convenience of construction, are generally rectangular, although the circular form is more economical as regards friction. Wherever they pass through watertight bulkheads they are provided with valves which, in case of accident and flooding, close automatically.

In living spaces the fresh-air inlets should be so placed and trimmed or protected by baffles that the streams of air will be broken up and so distributed as to prevent drafts. In cold weather, the introduction of cold air in heated (or often superheated) rooms exposes the occupants to unpleasant and dangerous chilling drafts. It is desirable therefore that the incoming fresh air should be moderately warmed before its admission and diffusion. This can be done by placing the steam coils used to heat the compartments in small chambers through which the air is made to pass. This decided improvement in ventilation is being tested in our Navy, and it is hoped that it will be found of general applicability.

Temperature and Humidity.—The temperature and humidity of ships deserve mention. They are heated within by boilers, engines, steam pipes, chemical changes in the cargo, galleys and ovens, and without by the sun. It is generally considered desirable to scatter the auxiliary engines (dynamos, windlasses, condensers, motors, etc.) in various parts of the ship so that in case of damage or accident some may be left in a serviceable condition. The compartments in which they are placed, as well as contiguous rooms, are thus made hot and damp, and often difficult to ventilate. The necessity of such dispersion is beginning to be questioned by naval engineers and, should they conclude to concentrate all these engines within the strongest part of the citadel, where ventilation is generally very good, the comfort and hygiene of the ship will be much improved thereby.

Iron heats and cools rapidly; metal ships are exceedingly warm in summer and cold in winter. These extremes can be much diminished by inside wood sheathing, but this is liable to decay and to harbor vermin; moreover, on men of war, such combustible material is not permissible as it would considerably add to the danger of conflagration in an engagement. Solar heat is best excluded by awnings and curtains, often sprinkled with water, and by white paint on the outside. The awnings are much more effective if double, particularly if the inner canvas is dark-colored. While at anchor, in the tropics, the ship should have a line made fast to the stern so that its broadside may always be kept to the wind, and free ventilation by perflation secured. Besides thorough ventilation, no better method of cooling compartments on board ship has as yet been devised than the use of electric fans which stir the air and increase the cutaneous evaporation.

Dampness is quite marked in many parts of ships; it is the resultant of several causes: the high degree of relative humidity of the air, the water used for mopping, the breaking of the waves upon the decks, the leaks from steam pipes, the respiration of men crowded within very limited spaces. This moisture readily condenses upon the cool iron, especially at night, producing the phenomenon of "sweating," or formation of droplets of water on metal surfaces, often dripping into the bunks and a cause of much annoyance. During the summer, only good ventilation has any marked effect upon it, while in winter it is removed by the steam heating. Some mitigation of this evil is obtained by using cork paint on all sweating surfaces, that is to say, ordinary paint sprinkled with granulated cork and covered with a smooth layer of zinc white. Asbestos cloth has also been recommended.

The old pernicious method of washing wooden decks by first flooding them with water is fortunately gradually disappearing. The washing of decks should be done with as little water as possible, wetting only small portions at a time and drying thoroughly, and preferably on sunny days, in order to prevent prolonged dampness. The lower decks, especially, should be mopped only when necessary to insure cleanliness. By sprinkling clean sand and sawdust over them, wooden decks can be preserved from much soiling. Simple mopping or scrubbing in places where required, together with holystoning and dry rubbing, will generally accomplish all that is necessary.

The use of linoleum varnished over with shellac as a deck covering and dressing, now general in the Navy, renders the decks neat, clean and free from the dampness which formerly resulted from their frequent washing. This covering is particularly of sanitary value in the living and messing spaces below the main deck. But to fulfill its purpose and really improve the healthfulness of ships it requires constant attention. The shellac should be put on freely so that the linoleum does not become exposed, stained and cracked. The linoleum, when worn and torn, permits an unseen accumulation of filth and moisture underneath it, admirably suited to the proliferation of disease germs. When in that state it is worse than useless and had far better be removed.

If the cooling of the living spaces is always difficult in summer, their heating in winter is easily accomplished. Steam heating, through coils, is the method generally used. Hot water heating would give a more moderate and equable warmth, but is of more difficult and costly application. Heating must always be accompanied by suitable and adequate ventilation, preferably with air moderately warmed as already explained.

Personal Hygiene.—In the Navy, where men must inevitably live in close contact, personal hygiene is even more essential than in the Army. Body cleanliness has become one of the characteristics of our Navy personnel and is effectually maintained by force of public opinion aboard and the instrumentality of disciplinary measures. "On board ship the recruit who shows a disposition to eschew the bath is always an object of the crew's active attention and, if necessary, a scrubbing is administered to initiate the change of habit" (Rep. Surg. Gen., 1908). Cleanliness of linen is as essential as that of the body, for not only is soiled linen malodorous but even more liable to disseminate germs of disease than the skin itself. Since the infection complicating gunshot wounds is the result of the dirt on skin and clothing, rather than on the missile, all authorities recommend that prior to an engagement, soldiers and sailors should

bathe and put on clean underwear and outer garments; if this be advisable on land it is still more so aboard where the danger from shell wounds is much more serious.

Ample bathing facilities, in the form of shower-baths, are required on board ships, especially for the engineer's force whose perspiring bodies are often begrimed with dirt and oil. Salt- and soft-water baths should be provided. It has been reported that the use of soft-water for this purpose is not as general as it might be in our Navy. Complaints have also been made that sometimes the salt water is so hot when it reaches the showers (having circulated through the distillers) that it renders them almost useless.

Swimming is for the sailor one of the most valuable of accomplishments, therefore one which he should be obliged to acquire, since it may be the means of saving his own life or that of his comrades. Swimming, besides cleaning the body, is a capital exercise and, were it for that reason alone, should be encouraged whenever practicable. It is necessary, however, to use some caution and ascertain that the water is reasonably pure. Most of the harbors frequented by our ships are more or less polluted with sewage from cities; in such places, therefore, the men should only be allowed to go swimming during floodtide. There is also danger of infection when swimming on sides of ships near where the flush from the heads (water-closets) is ejected.

The floors of water-closets should be of cemented concrete or tiling and made thoroughly impervious. Unless well constructed and kept in good repair, the jarring and vibration of the ship are quite likely to cause cracks and fissures in them, which become receptacles for urine and washings and the cause of offensive smells. The use of valves and vent pipes is necessary in water-closets to prevent "blowing" as the ship rolls and the discharge of tainted air in the compartments. In the best form of closet the outlet of the pan is closed by two valves so arranged that only one opens at a time. In closets placed below the water line and where, therefore, discharge by gravity is impossible, the flushing is effected by a hand pump. The flush water should not be hot; if the heated water from the distillers is used, it may constitute a nuisance on account of the odor-laden steam arising from the fixtures.

Considering the very offensive and repulsive odors emanating from unclean mouths and decayed teeth, especially in crowded spaces, oral hygiene must receive careful attention. The use of the toothbrush and tooth powder should be encouraged, if not insisted upon. Toothpicks should likewise be provided and kept in canteens; the common practice of using

matches for toothpicks has been found to be responsible for a certain number of cases of inflammation and ulceration of the gums and other parts of the mouth. The employment of dentists in the Navy, as recommended by the Surgeon General, would fill an urgent need.

The ship's barber may be a potent agent in the transmission of various diseases from his hands, clothing, instruments and excretions, and must therefore be subjected to strict sanitary regulations. Some naval surgeons insist that every man on board should be required to shave himself and the barber's functions limited to hair cutting, but this is probably no more feasible than in the Army. Each person should at least have his own shaving implements and material, except soap which had better be used in liquid form or as paste (in tubes). Instruments used on different persons should be disinfected after each operation by immersion in alcohol and afterward in a strong solution of either formalin or cresol; clean towels must be supplied each customer.

Tattooing, formerly very prevalent in the Navy, and still too common, is a serious evil to be entirely suppressed, one which, in the opinion of the Surgeon General, calls for prompt and vigorous official action. It is well known that this practice, as dangerous as it is absurd, is a vehicle for the transmission of constitutional and cuticular diseases; cases of syphilis and tuberculosis, even of death from blood-poisoning, having been caused by it.

The danger of the communication of diseases by the saliva, from the mouth-to-mouth use of common drinking cups, has long been realized in the Navy, and the scuttle-butt cup an object of suspicion and apprehension. This difficulty has been removed by the ingenious device of Surgeon Gates, U. S. Navy, known as the "Gates sanitary scuttle-butt attachment," which consists of special trumpet-shaped terminals out of which the water bubbles up, so that a man may drink without contact of the lips to the pipe, the flow being governed by a spring faucet, and the overflow passing into the expanded end of the surrounding drain. This device also saves water and time. On ships not provided with this sanitary attachment the cup should be kept submerged in a solution of formalin (1/2500).

On board ship, where the danger of communicating infectious diseases by contact is so great, nothing is better calculated to maintain a high standard of health and cleanliness than individual inspections of the enlisted personnel at regular times, by a medical officer. For instance, once a month, each man, stripped, should pass before the surgeon and his genital organs and skin be rapidly examined. Thus are venereal and cuta-

neous diseases discovered and habits as to cleanliness ascertained. This examination will prompt the men to report venereal affections soon after they break out, which is in the interest of good hygiene, and induce the uncleanly to make more frequent use of the bath.

Food.—The navy ration has been described in another chapter. It is in every way satisfactory as to quantity and quality, the commanding officer having ample authority to avail himself of local markets whenever desirable. In long cruises, however, fresh supplies may become scant and the diet somewhat monotonous, with deficiency of vegetable components and an excess of preserved meats. Most war ships and transports are provided with ice machines and cold storage so as to insure fresh meat and other perishable supplies for several weeks. The chief trouble in feeding the enlisted men of the Navy, as of the Army, is to secure the services of competent cooks in sufficient number, so that the components of the ration may be best utilized and always well prepared and served. Medical officers, in both services, cannot devote too much time and attention to the composition and preparation of the diet, under the various conditions of duty and climate. A consolidated mess has decided advantages over divided messes, but, for its success, requires a competent and zealous commissary steward and the intelligent supervision of officers.

In order to prevent scurvy and other detrimental effects of a prolonged salt-meat diet, the Revised Statutes require that all vessels bound across the Atlantic and Pacific, or around Cape Horn or Cape of Good Hope, or engaged in whaling or sealing, shall carry a sufficient supply of lemon-juice or lime-juice, and vinegar.

Water-supply.—This is an easy question on board war ships, transports and steam liners, all supplied with evaporators and distillers, and where only distilled water is allowed for drinking and culinary purposes. It is to be remembered, however, that distilled water, although free from organisms and therefore incapable of transmitting infectious diseases, may have an unpleasant and repulsive odor and taste, and possibly cause intestinal irritation, when the raw water is pumped from shallow, polluted harbors.

In ports where cholera, typhoid fever or dysentery prevail, or where the harbor is contaminated with much sewage or animal refuse, the use of harbor water on any of the decks should not be permitted.

In the absence of a distilling apparatus, no water should be taken on board without previous examination and approval by the ship surgeon, if practicable. The storage of such water is sometimes a matter of difficulty. Galvanized-iron tanks are best for the purpose; they should be coated

with cement to prevent the action of the water upon the iron, and have large manholes for purposes of inspection and cleansing. When an emergency requires the use of hogsheads or casks, their interior should be thoroughly charred, so that the water may not become tainted by the decomposition of the substances it extracts from the wood. The amount needed for drinking, cooking, ablutions and washing of clothing should be calculated on the basis of 4 gallons daily per capita.

DISINFECTION OF SHIPS.

Clothing, bedding, carpets, hangings, etc., are to be treated as described under *Disinfection*.

The hold of vessels may be disinfected by one or more of the following processes:

(a) Sulphur dioxid generated by burning sulphur, 5 pounds per 1000 cubic feet of air space, or liberated from 10 pounds of liquid sulphur dioxid, sufficient moisture being present; time of exposure 24 hours in metal ships and 48–72 hours in wooden ships. When the cargo cannot be removed, the sulphur should be generated from a furnace to minimize the danger of fire.

(b) Flushing with force pumps or washing of all surfaces with a solution of bichloride of mercury (bichloride 1 part, hydrochloric acid 2 parts, water 1000).

(c) Flowing steam for the empty hold of iron steamers, or at least that part of it which is above the water-line, utilizing for the purpose the steam pipes generally provided for use in case of fire.

In the case of all vessels treated for yellow fever or plague infection, fumigation by sulphur must precede everything else in order to insure the destruction of mosquitos, rats and other vermin. In wooden vessels sulphur must also be used first, for water would seal many of the cracks and prevent effective gas penetration.

Before applying the bichloride solution there should be a thorough mechanical cleansing of all parts requiring it, with lye and a stiff brush.

The living apartments, cabins and forecastles of vessels are disinfected by one or more of the following methods:

(a), (b) and (c) as above, the destructive action of the sulphur on property being borne in mind. For application to polished woods, bright metals and other surfaces injured by the bichloride, a 5 per cent. solution of formalin or carbolic acid should be preferred.

(d) Exposure to formaldehyde gas; the usual method for cabins.

Vessels are seldom so badly infected as to need disinfection throughout; the parts which require it, and the best methods to effect it must first be determined. Special measures are called for with each disease; thus, with cholera, typhoid fever and dysentery particular attention must be paid to the water, clothing and bedding; especial efforts should be directed against mosquitos in yellow fever and malaria; against rats and vermin in plague; while in small-pox and other exanthematous diseases, the usual careful disinfection of living compartments is required.

As a rule, the cargo and stores do not need disinfection, excepting when consisting of rags or other absorbent articles, household goods or food products coming from infected localities. In the case of plague infection, repeated sulphur fumigations are also necessary before unloading the cargo, in order to insure the destruction of all rats. The ballast is liable to infection and its removal may be required.

THE SICK BAY.

The hospital or infirmary of the ship should be so located as to have as much light and air as possible, with a minimum of noise and motion. On war vessels it is generally on the berth deck, abaft of the forward turret. It should be borne in mind that the further aft it is, the less motion and noise will disturb it, and the less the liability to flooding in case of storm; the facilities for isolation will also be better and the danger of disseminating infection less. As a rule, the sick bay in our Navy combines most of the advantages which it is practicable to secure for the sick and wounded afloat. It is thus described by Surgeon-General Rixey:

"Turning to the most modern type of ship, like the "Louisiana" or "Pennsylvania" or "Connecticut," we find a relatively commodious, admirably equipped emergency hospital, consisting of wards, isolation room, dispensary, bathroom, closet, and operating room, modern in all its appointments. All the indispensable requisites are provided and placed in a manner that is irreproachable for operation, dressing, and all medical care. In addition to modern aseptic furniture, instruments of precision, laboratory facilities, an elaborate surgical outfit and sterilizers, not to mention an abundant store of dressings and other material, there is good light and ventilation, hot and cold water, ice, etc., and, above all, attendance by trained nurses qualified to undertake all the duties of their calling" ("Keen's Surgery").

Unfortunately, the sick bay is rarely, if ever, protected by heavy armor, so that in war time, at the beginning of an engagement, it becomes untenable and must be abandoned. A naval battle is very different from a land fight, often more severe and destructive. Its issue is not decided by rifle fire, as upon land, but by heavy ordnance, so that wounds are mostly of a much more serious character. Combatants and non-combatants are equally exposed above the water-line; nor is there entire safety below it, the men thus located being in greater danger of mines and torpedoes.

Where to collect the wounded during an engagement, so that they may be relatively safe and not in the way of combatants while receiving appropriate treatment, is an important problem which, in the event of war, would have to be solved on each ship in accordance with its structural type. Such a place must be sought behind the heavy armored belt, preferably below the water-line; the spaces between the bunkers can be utilized, since coal affords relative protection. Accessibility is a great advantage, but does not matter so much as safety.

The great value of such a protected dressing-station in saving lives without interfering with the fighting efficiency of the ship, has been recognized in our Navy; it is now provided for, behind heavy armor, on battle-ships building or being planned, and fitted with all necessary appliances for lighting, ventilation, steam connections for sterilizers, hot and cold water, water-closets, lockers, etc. In ordinary peace time this compartment is to be utilized for stores or other purposes.

To this main or central dressing-station, all the wounded, or as many as it will accommodate, must be transported during a battle. They are at first collected at first-aid stations established wherever convenient, and thence carried below to the dressing-station as soon and whenever it is practicable to do so. If deemed in the interest of the wounded, secondary dressing-stations may be temporarily established, one forward and one aft, in partly protected and readily accessible positions.

The transfer of the wounded on board ship during an engagement is always attended with more or less difficulty. The stretchers in use in our Navy are the "apron stretcher" of Lung which has rendered excellent service in the past, and "Stokes' splint stretcher." The latter is doubtless the best apparatus as yet devised for the purpose; it consists of a hollow frame of strong wire-netting braced with iron rods, partitioned below to accommodate the legs separately. On account of its rigidity it can be used as a splint for any part of the body requiring special protection. It can be handled in any position, slid on deck and lowered through the hatches.

The "hammock-stretcher" of Auffret, used in the French Navy, is constructed somewhat on the same principles, but is curved under the buttocks to afford support, and not partitioned.

FIG. 228.—The Stokes splint stretcher.

HOSPITAL SHIP.

The hospital ship, in peace as in war, is now recognized as a necessary component of a fleet. The Navy Regulations characterize it as follows:

"A hospital ship being assimilated to a naval hospital on shore, will be commanded by a naval medical officer not below the grade of a surgeon detailed by the Navy Department. Such vessels will be manned by a

merchant crew and officers and, in addition, a detail from the Hospital Corps of the Navy for carrying out the service to which the vessel is specially assigned."

"All hospital ships shall be distinguished by being painted white outside, with a horizontal band of green about a meter and a half in breadth. The boats shall be distinguished by similar painting. In accordance with the terms of the Geneva Convention, all hospital ships will fly the Geneva Cross flag at the main in lieu of the narrow pennant or coach whip."

"The neutrality of the hospital ship will at all times be preserved."

During an engagement, the hospital ship will seldom be able to render much service. Any attempt to do so must be clearly in pursuit of its humane mission and always at its own risk and peril. It may help the wounded and crews of sinking ships after they have surrendered, or when in such condition as to have ceased to be a factor in the fight. Most of its efficient work, however, will be performed at the close of the battle.

Hospital ships for the Army or Navy, whether constructed for the purpose or adapted from the merchant marine, should combine certain essential features, described by Surgeon W. C. Braisted, U. S. Navy, as follows:

Hull: Of iron or steel.

Size: Not less than 4,000 tons.

Compartments: At least four good water-tight compartments.

Bilge keels.

Length: Not less than 350 feet.

Beam: Not less than 40 feet.

Steaming radius 5,000 miles.

Free board: There should be as much free board as possible consistent with steadiness and safety.

Decks: At least four good unincumbered decks.

1. Superstructure deck.
2. Upper deck.
3. Main deck.
4. Lower deck.
5. Hold.

Disposition of Space.

Superstructure Deck.—Navigating officers with offices, staterooms, and mess-rooms, forward; senior medical officer's adjoining captain's.

Aft: Infectious ward; removable, mosquito-proof, double canvas top;

closets and washrooms with separate plumbing; utensil closet, nurses' room, and medical attendants' room.

Extreme aft: Disinfector for infected material.

Boats: At least two steam launches specially equipped for transport of sick.

Junior medical officers have staterooms near sick officers' quarters, and medical officers' mess in the wardroom of sick officers.

UPPER DECK, *Forward.*—Ward for sick officers: At least 2 suites of communicating rooms for officers of high rank, with bath and closet in one room and standing bed, stationary eating table and clothes locker in the other.

Other rooms: At least 10 single rooms for officers of commissioned rank, except cadets. There should also be a mess-room with mess table, sideboard, library, easy chairs, pantry, and dumb-waiter. At the after end there should be common closets, baths, and washroom.

Aft: Medical ward, with standard bunks single or double banked, according to plan, with eating board, spit cups, and ditty-box attached. Head nurse's room. In rear of ward: Baths, closets, washroom, and examining room. Starboard side engine-room uptakes: Dispensary with Navy standard fittings complete, and adjoining stateroom for pharmacist. Port side:

1. Lounging- and smoking-room for officers.
2. Commissary's office.
3. Medical records and business office.

MAIN DECK, *Forward.*—Medical convalescent ward arranged the same as the medical ward.

Aft: Surgical ward, with operating room, X-ray and electro-therapeutic room, and small dark and developing room on starboard side forward; recovery room adjoining. Aft, on port side of ward, pus operating room, and dressing room, baths, closets, and washroom; on starboard side, head nurse's room, clinical bacteriological room and dentist's office, outfit complete, Navy or Army standard, with working library. Portside uptakes: Mess-rooms for convalescents, with pantries and warming room. On starboard uptakes, galleys, bakeshops, etc. Adjoining convalescent ward, forward, ward for noncommissioned officers, with adjoining mess-room and pantries; closets and baths on port side connecting with same for convalescent medical ward. Aft of galleys: Mess-room for nurses, hospital stewards, etc. Pharmacist to mess with warrant officers.

LOWER DECK, *Forward Extreme.*—Petty officers' mess-room, quarters, bath, closets; corresponding space on main deck above for crew.

Mid-deck Space.—Steam laundry, port side forward. Ice machines (two), capacity 3–4 tons, starboard side. Disinfector, drying room, freight elevator, cargo ports, cells for prisoners, and padded cells for insane. Dynamo room.

Aft: Crew space, with mess tables, Navy standard lockers, library, and master-at-arms office and stateroom. Further aft, nurses, with mess tables, lockers, Navy standard pattern, books of instruction, lecture room, berths. Closets with washrooms extreme aft.

HOLD, *Forward.*—Storerooms for vegetables and meats, pantries for officers' mess, storeroom for perishable goods, and dead-room, with Navy standard outfit.

Aft: Engineer stores, paymaster stores, medical stores for use on board ship and for distribution.

Extreme Aft: Two Army regimental hospitals each for 1,000 men, with wheeled litters, for use with landing parties.

Means of transportation for sick and wounded:

1. Wheeled carriage.
2. Stretchers, Stokes' and Army.
3. Cargo ports.
4. Electric "Otis" light-running elevator at site of after cargo ports, running to all decks.
5. Davits and whip.
6. Steam launches.
7. Ladders.

The entire ship should be screened.

Medical and Hospital Corps Personnel for a Ship of 200 *Beds.*—Medical: One medical officer in command of ship; four medical officers to attend the patients.

Hospital Corps:

Noncommissioned officers: Five (5).

Privates: Thirty-five (35).

CHAPTER XL.

QUARANTINE.*

By quarantine is meant the employment of such measures as are deemed necessary to avoid the introduction or transmission of disease from one country or locality to another.

The word itself is derived from the Italian *quarantina*, meaning forty, the number of days during which ships were formerly detained. The first maritime quarantine was instituted in 1403 at Venice, but measures to prevent the spread of plague had been previously enforced by several Italian states.

All infectious diseases may be subjected to quarantine. For many years quarantinable diseases were limited to cholera, typhus, small-pox, and yellow fever. The statutes of New York now comprise as such, "yellow fever, measles, cholera, typhus, small-pox, scarlatina, diphtheria, relapsing fever, and any disease of a contagious, infectious, or pestilential character which shall be considered by the health officer dangerous to public health."

Under present United States regulations, the quarantinable diseases are cholera, typhus fever, plague, small-pox, yellow fever, and leprosy.

The period of detention imposed on ships and persons in quarantine for any disease should not exceed the usual period of incubation of said disease.

Quarantine may be maritime or inland; inland quarantine may be interstate, state, or municipal.

Maritime quarantine is directed against the introduction of disease, chiefly from abroad, through the medium of vessels, their crews, passengers and cargoes. It begins at the port of departure. The United States regulations require that masters of vessels departing from any foreign port, or from any port in the colonies of the United States, for a port in the United States or its colonies, must obtain a bill of health signed by the proper consular or medical officer of the United States. Should

*Based on laws and regulations of the United States as executed by the Public Health and Marine Hospital Service.

such vessels call at intermediate ports they must procure at said ports a supplemental bill of health.

Are usually exempt from this requirement all vessels clearing from adjacent Canadian and Mexican ports unless quarantinable diseases prevail thereat.

Before issuing the bill of health the consular or medical officer will satisfy himself that the vessels, passengers, crews and cargo have complied with all the quarantine regulations of the United States.

Quarantine stations must have adequate provisions for the boarding and inspection of vessels; appliances for their mechanical cleansing and disinfection; a hospital for the treatment of contagious diseases, and another for the treatment of non-contagious diseases; barracks for the detention, in groups, of persons who have been exposed to contagion; also laboratory, steam laundry, crematory, etc.

Every vessel subject to quarantine inspection, entering a port of the United States or its colonies, shall fly a yellow flag at the foremasthead and be considered in quarantine until given free *pratique.*

SPECIAL UNITED STATES QUARANTINE REGULATIONS.

For Cholera.—For the purpose of these regulations, five days are considered as the period of incubation.*

If the vessels carry persons from cholera-infected ports or places, a bacteriological examination should be made of any cases of diarrhea to exclude cholera before granting free pratique.

"If cholera has appeared on board, remove all passengers from the vessel and all of the crew, save those necessary to care for her; place the sick in hospital. Carefully isolate those especially suspected, and segregate the remainder in small groups. No communication should be held between these groups. Those believed to be especially capable of conveying infection must not enter the place of detention until they are bathed and furnished with non-infected clothing; nor shall any material capable of conveying infection be taken into the place of detention, especially food and water."

The water-supply of the vessel, if suspected of infection, must be disinfected, then discharged and the tanks thoroughly rinsed.

Living apartments and other portions of the vessel, as well as all baggage, effects and articles of cargo, which have been exposed to infection, must be disinfected.

*International Sanitary Convention of Paris, 1903.

Water ballast taken on at a cholera-infected port should be discharged at sea and the tanks disinfected.

For Plague.—For the purpose of these regulations, five days shall be considered as the period of incubation.*

At ports where plague prevails, every precaution must be taken to prevent the vessel becoming infected through the agency of rats, mice, flies, fleas, ants, or other animals. The vessel should not be at the dock, or anchor near any place where such animals may gain access to it. Access through the cables is prevented by tarring them and providing them with inverted cones. Sulphur fumigation should be resorted to before and during loading. Communication between the vessel and shore must be reduced to the minimum absolutely necessary.

Careful observations should be made during voyages from plague-infected ports to ascertain any marked sickness or increased mortality among the rats on shipboard. Experience has shown that an outbreak of plague in man is almost invariably preceded by an increased mortality among rats and mice.

Suspected vessels coming to quarantine shall be anchored at a sufficient distance from the shore or other vessels to prevent the escape of rats by swimming.

For persons actually exposed to the infection the administration of antipest serum is regarded as a valuable prophylactic measure. If any cases have occurred during the voyage, passengers and crew should be examined with special reference to the glandular regions. Doubtful cases, especially of the pneumonic type, may be subjected to bacteriological examination before the vessel is released.

The sick are sent to the hospital. The crew and passengers are removed and segregated into small groups and held under close observation for five days. Any person who has been directly exposed should be bathed and his belongings disinfected before removal.

Nothing shall be thrown overboard from the vessel, not even deck sweepings. Such material will be burned in the furnaces of a steamer or in a place specially designated, but not in the galley.

As soon as practicable there shall be a thorough and simultaneous disinfection of all parts of the vessel with sulphur dioxid for the destruction of rats and vermin. The killing of escaping rats should be provided for by a water guard in small boats. No person with abrasions or open sores must be employed in the handling of the vessel or her cargo. The rats will be subsequently gathered and burned, due precautions being taken

*International Sanitary Convention of Paris, 1903.

not to touch them with bare hands. With the cargo the disinfection is fractional; after twelve hours' exposure to sulphur dioxid, overnight, the upper layer of cargo is removed and placed on lighters exposed to the sun; this process of disinfection by night and removal of successive layers of cargo by day is to be continued until the hold is empty.

For Yellow Fever.—For the purpose of these regulations, six days are considered as the period of incubation.*

While in an infected port, the vessel must lie at approved moorings in the open harbor and not approach the wharves; nor must the crew be allowed ashore. Every possible precaution should be taken to prevent the introduction of mosquitoes, and their breeding on board. Before the stowing of cargo or receiving of passengers the vessel should be carefully fumigated.

Inasmuch as the yellow-fever mosquito (stegomyia) occurs naturally from the Gulf of Mexico to Virginia, it follows that measures of quarantine at southern ports need be much stricter than further north where the stegomyia is not found, except when imported and then only for a short time.

If the vessel has properly complied with the quarantine regulations to be observed at foreign infected ports, and arrives at a northern port (north of the southern boundary of Maryland) without sickness, after six days from the time of departure, she may be admitted to pratique immediately after fumigation, without detention. If she arrives in less than six days she may be admitted to pratique without further detention than is necessary to complete the six days. If arriving after a longer voyage than ten days, she may be subjected to the full period of detention, on the ground that a case of yellow fever might have occurred aboard and recovered, thus making her infection possible.

Vessels shall be held in quarantine if arriving at a port south of the southern boundary of Maryland in the season of close quarantine, May 1 to November 1 (directly or via a northern port), from a tropical American port, unless said port is known to be free from yellow fever.

If cases of yellow fever have occurred aboard, remove them to the hospital by screened ambulance or litter, and place them in a ward thoroughly protected against mosquitoes. Remove likewise and isolate all persons not required for the care of vessel; then destroy the mosquitoes on board by the simultaneous fumigation of all parts of the vessel by sulphur dioxid. If a fresh crew is available the vessel may now be released without further detention, reshipping the old crew left at the quarantine station on her next outward voyage.

*Second Sanitary Convention of American Republics, Washington, 1905.

Vessels need not be subject to quarantine when engaged in the fruit trade, provided they have fully complied with the special rules and regulations enacted for their guidance and benefit.

Passenger traffic without detention may also be allowed during the close quarantine season from infected ports to ports in the United States, even south of the southern boundary of Maryland, when all passengers and crew are immune to yellow fever, the vessel is of iron and in first class sanitary condition, and every precaution has been taken in the infected port to prevent the ingress of mosquitoes.

The disinfection of baggage for yellow fever is not required unless the quarantine officer has sufficient grounds to believe that it harbors mosquitoes.

For Small-pox.—For the purpose of these regulations, fourteen days shall be considered as the period of incubation.

On all vessels arriving with small-pox on board, or having had small-pox during the voyage, any of the passengers and crew who have been exposed to the infection must be vaccinated or detained in quarantine not less than fourteen days, unless they show satisfactory evidence of recent successful vaccination or of having had small-pox.

Such vessels need not be quarantined further than the removal of the sick, the disinfection of all compartments, baggage and objects that have been exposed to infection, and such vaccination of the personnel as required in the previous paragraph.

For Typhus Fever.—For the purpose of these regulations, twelve days shall be considered as the period of incubation.

Vessels in otherwise good sanitary condition, but having typhus fever on board which has been properly isolated, need not be quarantined further than the removal of the sick, and disinfection of the compartments and their contents exposed to infection.

If the cases have not been isolated, or the disease has spread, the vessel will be quarantined, the sick removed, and all persons who have been exposed to the infection detained under observation.

Living compartments and all other parts of the vessel exposed to the infection, as well as baggage and effects, must be disinfected.

For Leprosy.—The period of incubation of this disease is still undetermined.

Vessels arriving at quarantine with leprosy on board shall not be granted pratique until the leper, with his baggage, has been removed to the quarantine station, and the living compartment or part of the vessel which has been exposed to infection properly disinfected.

No alien leper shall be landed. He will be detained at the quarantine station until again put aboard the vessel that brought him, for his return to the port of embarkation, as provided by law.

INTERSTATE QUARANTINE.

For the purpose of these regulations the quarantinable diseases are the same as in maritime quarantine, namely: cholera, plague, yellow fever, small-pox, typhus fever, and leprosy.

Under existing law the Public Health and Marine-hospital Service cooperates with and aids State and municipal boards of health in the execution and enforcement of the rules and regulations of such boards to prevent the introduction of contagious or infectious diseases into the United States from foreign countries and into a State or Territory from another State or Territory; and for such ports and places within the United States as have no quarantine regulations under State or municipal authority, or adequate regulations to prevent the introduction of such diseases into the United States or into a State or Territory from another State or Territory, the Secretary of the Treasury shall, if he deems necessary, make such rules and regulations as may be required to that end. If the States and municipalities fail or refuse to execute and enforce these regulations the President is authorized to execute and enforce them and adopt such measures as in his judgment shall be necessary for the purpose.

The general principles governing interstate quarantine are the same as those pertaining to maritime quarantine, but instead of dealing with ships as media of transportation we must deal with trains, steamboats, and coaches.

The law requires that State and municipal health officers shall immediately notify the Public Health and Marine Hospital Service, by telegraph or letter, of the existence of any of the quarantinable diseases in their respective States or localities. All cases of quarantinable diseases or suspected of belonging to this class shall be at once reported by the physician in attendance to the proper authorities. These notifications are of extreme importance and must be strictly enforced so that suitable measures may be taken before the epidemic acquires headway and begins to spread.

Persons suffering from a quarantinable disease, or suspected to be so, shall be removed to a hospital or otherwise isolated until no longer capable of transmitting the disease. Those who have been exposed to the

infection shall be isolated, under observation, for such a period of time as may be necessary to demonstrate their freedom from it.

The apartments occupied by persons suffering from quarantinable disease, and adjoining apartments when deemed infected, together with articles therein, shall be disinfected upon the termination of the disease.

No common carrier shall accept for transportation any person suffering with a quarantinable disease, nor any infected article of clothing, bedding, or personal property. Bodies of persons who have died from any such disease shall not be transported save in hermetically-sealed coffins, and by the order of the State or local health officer.

In the case of yellow fever, a place shall not be considered entirely free from infection until after the expiration of eighteen days (namely, twelve days for incubation in mosquito and six days for incubation in bitten patient).

In addition to the national quarantine, State or municipal authorities may make such additional regulations as they deem necessary for the preservation of the health of the people within their jurisdiction.

Under interstate and State quarantine are included sanitary cordon, camp of detention, railroad quarantine, disinfection stations, and inspection service.

The sanitary cordon consists of a line of guards, military or civil, thrown around a district or locality, either to protect the same from the surrounding country when infected, or to protect the surrounding country from an infected district or locality. Sometimes a double cordon is necessary, the outer one embracing the whole suspected territory, the inner investing more closely the well-defined infected locality. Sanitary cordons have been mostly used in Europe and Asia to guard against the spread of plague and cholera, and in this country against the spread of yellow fever.

A camp of detention is a place to which persons from infected points can go or are sent, to be kept under observation a sufficient length of time to demonstrate whether they are or are not infected; if infected they are removed to a special hospital; if not, they are released after disinfection of their clothing and baggage.

Camps of detention should be established with due regard to site, water and drainage, and subjected to strict discipline. Every applicant must be examined by a physician before admission to ascertain the state of his health. His clothing and baggage are carefully inspected and, if need be, disinfected. All ingress and egress are allowed only through the established portal. The inmates are made as comfortable and

cheerful as possible, all proper amusements and entertainments being encouraged and promoted. Each person, on leaving camp, is given a certificate that he has passed the required period of detention.

Such places should be not confounded with *camps of refuge* which are simply residence camps established to receive the non-immune population of an infected community and where it can remain in comparative safety until the epidemic is stamped out.

Railroad and steamboat quarantine consists in restricting all egress from an infected State or locality to a few stations on railroad and steamboat lines, and maintaining an efficient system of inspection at those stations. Inspectors, properly uniformed, board all outgoing trains and steamboats and demand of each passenger a certificate from a health officer showing where he has been during the previous five or six days, according to the disease to be guarded against. In case of doubt, passengers are sent to camps of detention.

Municipal quarantine includes not only the measures necessary to prevent the introduction of disease into communities or its transmission from a city to neighboring cities and States, but also those required to prevent its spread within cities. It applies not only to the quarantinable diseases already described, but also to all other infectious diseases such as scarlet fever, measles, diphtheria and tuberculosis.

An important factor in municipal quarantine is the house-to-house inspection to ascertain the actual number of existing cases of disease. This naturally involves domiciliary quarantine or the exercise of restrictive measures against a particular house or part of a house; these are enforced by the stationing of guards to see that none but authorized persons enter or leave the infected premises.

It is very important that as many of the sick as possible should be removed to special hospitals, thus increasing the facilities and efficiency of administration and diminishing the number of foci of infection.

THE FOLLOWING ARTICLES OF THE SECOND INTERNATIONAL SANITARY CONVENTION OF THE AMERICAN REPUBLICS (WASHINGTON, D. C., 1905), BASED ON THE CONVENTION OF PARIS, 1903, HAVE SPECIAL INTEREST.

ARTICLE I.—Each government shall immediately notify other governments of the first appearance in its territory of authentic cases of plague, cholera, or yellow fever.

ARTICLE II.—This notification is to be accompanied, or very promptly followed, by the following additional information:

1. The neighborhood where the disease has appeared.
2. The date of its appearance, its origin and its form.
3. The number of established cases, and the number of deaths.
4. For plague, the existence among rats or mice of plague or of an unusual mortality; for yellow fever, the existence of *stegomyia fasciata* in the locality.

*   *   *   *   *

ARTICLE IV.—The notification and the information prescribed in Articles I and II are to be followed by further communications dispatched in a regular manner in order to keep the governments informed of the progress of the epidemic.

These communications which are to be made at least once a week, and which are to be as complete as possible, should indicate in detail the precautions taken to prevent the extension of the disease.

They should set forth: first, the prophylactic measures taken relative to sanitary or medical inspection, to isolation and disinfection; second, the measures taken relative to departing vessels to prevent the exportation of the disease, and, especially under the circumstances mentioned in paragraph 4 of Article II, the measures taken against rats and mosquitoes.

ARTICLE V.—The prompt and faithful execution of the preceding provisions is of the very first importance.

The notifications have only a real value if each government is warned in time of cases of plague, cholera and yellow fever, or of suspicious cases of those diseases occurring in its territory. It cannot then be too strongly recommended to the various governments to make obligatory the declaration of cases of plague, cholera or yellow fever, and the giving of information concerning an unusual mortality of rats and mice especially in ports.

ARTICLE VI.—It is understood that neighboring countries reserve to

themselves the right to make special arrangements with a view of organizing a service of direct information between the chiefs of administration upon the frontiers.

ARTICLE VII.—Information of a first case of plague, cholera or yellow fever does not justify, against a territorial area where it may appear, the application of quarantine measures.

Upon the occurrence of several non-imported cases of plague, or a non-imported case of yellow fever, or when cases of cholera form a focus, the area is to be declared infected.

ARTICLE VIII.—To limit the measures to the affected regions alone, governments should only apply them to persons and articles proceeding from the contaminated or infected areas.

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But this restriction should only be accepted upon the formal condition that the government of the infected country shall take necessary measures, 1, to prevent, unless previously disinfected, the exportation of articles coming from the contaminated area and, 2, to prevent the extension of the epidemic; and provided further, there be no doubt that the sanitary authorities of the infected country have faithfully complied with Article I.

When an area is infected, no restrictive measure is to be taken against departures from this area which have occurred five days at least before the beginning of the epidemic.

ARTICLE IX.—That an area should no longer be considered as infected, official proof must be furnished:

First, that there has been neither a death nor a new case of plague or cholera for five days after isolation, death, or cure of the last plague or cholera case. In the case of yellow fever the period shall be eighteen days, but each government may reserve the right to extend this period.

Second, that all the measures of disinfection have been applied; in the case of plague, that the precautions against rats, and in the case of yellow fever that the measures against mosquitoes, have been observed.

ARTICLE X.—The government of each country is obliged to immediately publish the measures which it believes necessary to take against departures either from a country or from an infected territorial area.

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ARTICLE XI.—There exists no merchandise which is of itself capable of transmitting plague, cholera, or yellow fever. It only becomes danger-

ous in case it is soiled by pestous or choleraic products, or, in the case of yellow fever, when such merchandise may harbor mosquitoes.

Article XII.—No merchandise or objects shall be subjected to disinfection on account of yellow fever, but in cases covered by the previous article the vehicle of transportation may be subject to fumigation to destroy the mosquitoes. In the case of cholera and plague, disinfection should only be applied to merchandise and objects which the local sanitary authority considers as infected.

Nevertheless, merchandise or objects may be subjected to disinfection, or prohibited entry, independently of all proof that they may or may not be infected.

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Article XIII.—In the case of cholera and plague there is no reason to forbid the transit through an infected district of merchandise and objects which are so packed that they are not exposed to infection in transit.

In like manner, when merchandise or objects are so transported that, in transit, they cannot come in contact with soiled objects, their transit across an infected territorial area should not be an obstacle to their entry into the country of destination.

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Article XVI.—Letters and correspondence, printed matter, books, newspapers, business papers, etc. (postal parcels not included), are not to be submitted to any restriction or disinfection. In case of yellow fever, postal parcels are not to be subjected to any restriction or disinfection.

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Article XIX.—Baggage. In the case of soiled linen, bed clothing, clothing and objects forming a part of baggage or furniture coming from a territorial area declared infected, disinfection is only to be practised in cases where the sanitary authority considers them as contaminated. There shall be no disinfection of baggage on account of yellow fever.

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